February 1941

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FEB 10 1941

MACHINE DESIGN

In This Issue:

Theory of Elasticity in Practice

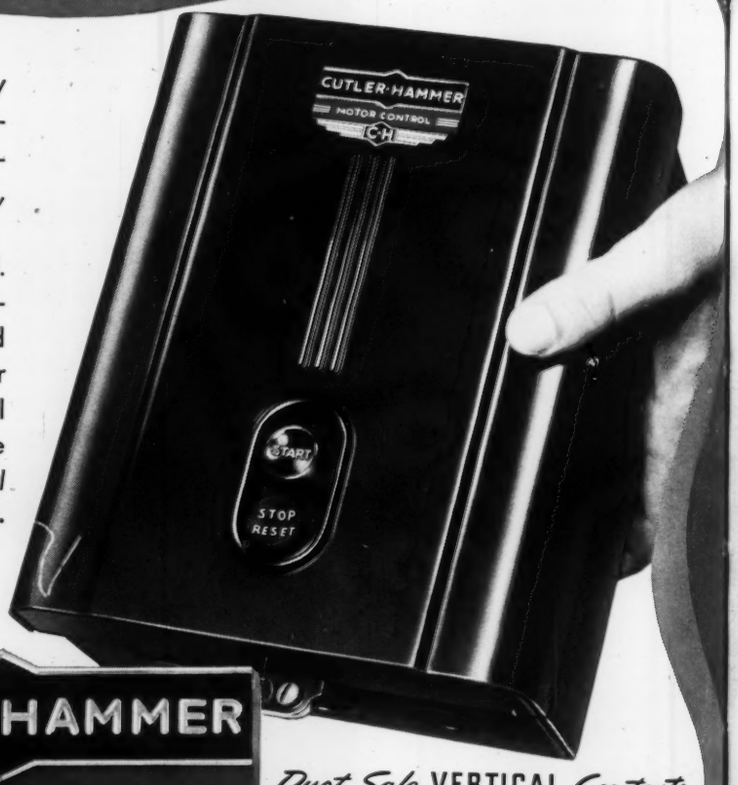
Infrared Hits High Production Note

Designing Open-Coil Helical Springs

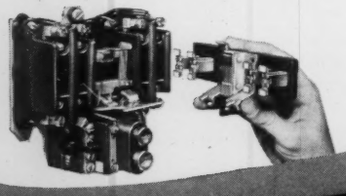
Doesn't It Beat All How DIRTY *Things Get!*

THE annual spring cleaning which is a bane in every housewife's life, is mute testimony to a fact of far-reaching significance to factory executives and maintenance men. *Dust is everywhere, gets in everywhere, and settles on horizontal surfaces.*

Dust is a destroyer where Motor Control is concerned. Dirty contacts mean trouble. Horizontal contacts collect dust. Vertical contacts stay clean. So, experienced and profit-minded factory men insist on Cutler-Hammer Motor Control . . . the control with dust-safe Vertical contacts. You too insist on Cutler-Hammer, and see the difference. CUTLER-HAMMER, Inc., *Pioneer Electrical Manufacturers*, 1310 St. Paul Avenue, Milwaukee, Wis.



Cutler-Hammer *Vertical* Contacts are the mark of *better* Motor Control, another extra dividend on Cutler-Hammer's unequalled specialized experience and decades of Motor Control leadership.



CUTLER-HAMMER
MOTOR CONTROL
C-H

Dust Safe VERTICAL *Contacts*

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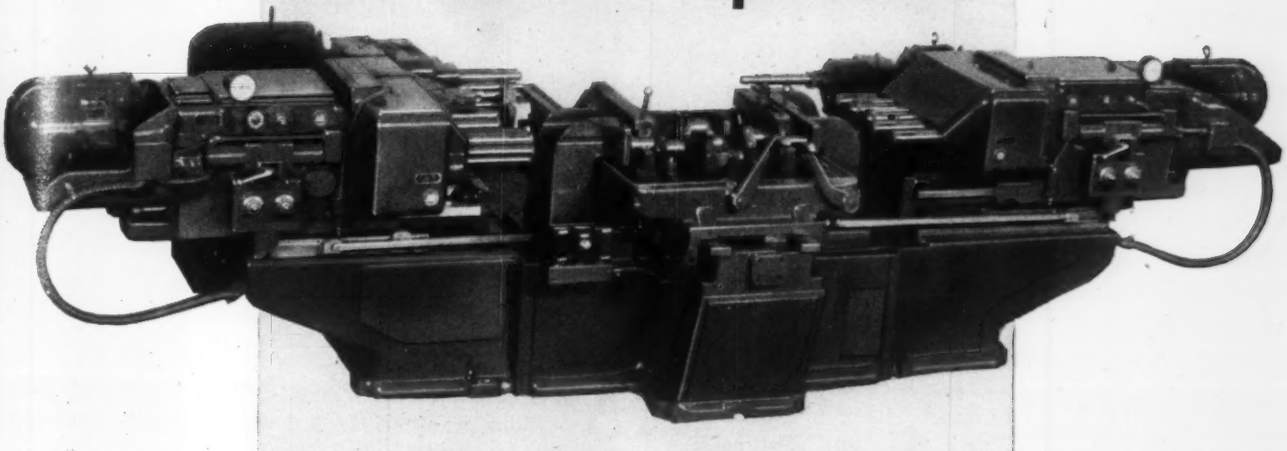
For Precision Operations



2-Way, 22-Spindle horizontal machine for miscellaneous operations on crankshaft, with 2-position index feature and hydraulic feed. Powered by four dynamically balanced Delco motors.

Dynamically Balanced DELCO MOTORS

Exceptionally smooth operation is a characteristic which makes Delco motors a particularly logical choice for precision machines. Not only are they manufactured with an eye toward reduced vibration through accurate machining and carefully maintained alignments, but, as a final step, all Delco motors are dynamically balanced in an accurate operation developed for Delco Products by General Motors Research engineers.

Delco motors have won the acceptance and approval of maintenance men by their over-all *ruggedness* . . . the result of Delco Products' conscientious manufacturing. Taping of stator winding goes well into lamination slots, and three dips and bakes are given to the stator while separate from the frame. Feet are massive, and integrally cast ribs in frame serve to increase strength as well as radiate heat. Inner race of bearing is locked on shaft, and hole in rotor and rotor key-way are in same plane, to prevent wobble. Finally, the baked enamel finish on Delco motors will withstand the hardest usage without chipping.

Cool operation, a vital factor in long motor life, is assured by many *extra* operations in the manufacture of Delco motors, as well as by sound design. For example, Delco Products grinds the outside of stator laminations for better contact with frame, and uses a frame type which provides all-round contact (except for space allowed for motor leads), as opposed to other types which provide contact at only three or four points. The use of extra ribs, which could be eliminated without affecting motor rating, is further proof of Delco's determination to place users' satisfaction above manufacturing economy.

Consult the Delco Products Engineering Department for recommendations.

Totally-enclosed, fan-cooled, ball-bearing Delco motor—flange-mounted.

DELCO MOTORS

DIVISION OF GENERAL MOTORS CORPORATION

DELCO PRODUCTS DAYTON, OHIO

Topics

OFFER by Revere Copper and Brass of $10,000 in prizes for suggestions from workmen to aid in speeding national industrial defense holds unusual interest for designers, because suggestions thus given may result in improvement in design of production machines. Most successful designers, of course, keep in close touch with shop operations and profit by reactions from actual operators of machines. The Revere statement points out how many notable industrial leaders—Edison, Chrysler, Knudsen, etc.—have risen from factory jobs. More than 2,000,000 men will be eligible for the award.

♦

CONTACT of air and subsequent formation of costly oxides is said to be prevented by a new material that forms a "perfect fluid blanket" on the surface of zinc in galvanizing. In addition, the material prevents radiation of heat from the surface of the bath and so effects tremendous economies. According to its sponsors, the fluid blanket will not be broken if the material is drossed through, if zinc is fed through it, or if wire and pipe are threaded through it.

♦

A NEW liquid chemical should be valuable to designers whose machines involve parts subject to sea-water corrosion. Called Tectyl, the chemical separates salt water from steel and forms an oily protective coating on the metal. Tectyl is electromagnetically attracted to steel and other conductive metals and forms polar film. Four grades are available, depending on film thicknesses. The thinnest can be used for cleaning, the thickest provides long-term protection from weathering. The Navy is now using Tectyl for many finish jobs.

♦

AS THE defense program progresses, one of the chief points of interest for designers is the extent to which design will be affected by shortage of materials or their allocation because of priorities, by the need for standardization and high production, etc. Significant signs in this direction have not become prominent yet, for the most part, but it has been suspected for some time that no new automobile models would be brought out this coming fall. Joseph W. Frazer, president of Willys-Overland, came out last month with just such a suggestion. His company has approximately $20,000,000 worth of government orders at present.

♦

AMONG the more interesting of recent applications of Fiberglas is a woven covering for small airplane wings. In a recent test a blow torch was applied to the covering to prove it wouldn't burn. Nor will it stretch, shrink or rot. Civil Aeronautics board is to test the covering further.

♦

THIRTY-FOUR electric motors, ranging in size from two 300-horsepower units down to two half-horsepower models, drive a mammoth new boring mill just put in operation at Westinghouse on waterwheel generators. Table of the machine weighs 88 tons and normally carries pieces up to 40 feet in diameter, although larger ones can be accommodated. Accuracy of the machine is four-thousandths of an inch, but by controlling temperature conditions this figure can be reduced.

♦

VARIOUS companies are taking extraordinary steps to assure continued defense production in ease of emergencies. Timken, for instance, is installing a reserve water system and an emergency fuel supply. One of the most spectacular steps along this line—borrowed from Europe—is a 1000-kilovolt-ampere mobile substation built by General Electric. Total weight including special chassis is 10 tons, and the unit can be hauled at speeds up to 40 miles per hour. In an emergency the substation need only be parked and grounded, incoming high tension lines attached and secondary lines fed out. The transformer is designed to take power from high voltage lines up to 44,000 volts and supply systems up to 4600 volts.

♦

SEVERAL times recently Topics has mentioned methods in use for transferring engineering drawings directly to the material from which parts are to be made. A method for sensitizing aluminum is mentioned in the latter part of this month's issue. In connection with the defense program, it is interesting to see that Lockheed Aircraft is using a huge camera—10½ feet high—to photograph drawings. Negatives are then enlarged on sensitized metal and the enlargements cut out.

MACHINE DESIGN

Applying Theory of Elasticity in Practical Design

By R. E. Orton
Chief Engineer
Acme Steel Co., Chicago

Part I

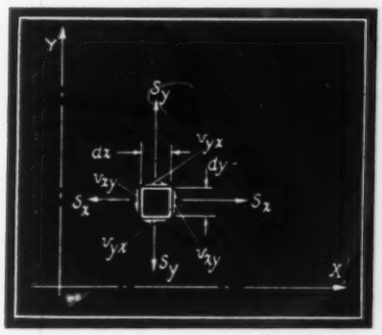


Fig. 1—Elemental prism under plane stress, showing positive directions of stress

APPLICATION of elastic theory by the design engineer bridges the gap between those problems that may be solved satisfactorily by elemental analysis and those of sufficient complexity to justify methods such as photoelastic analysis. While the majority of stress problems are handled with sufficient accuracy by the methods of the conventional "strength of materials," many are encountered by machine designers where these methods are seriously in error. Among such problems are shapes of sufficient regularity to permit the use of elastic theory, avoiding the necessity of resorting to the more time consuming experimental methods. Also, the qualitative application of elastic theory often assists in the interpretation of the photoelastic fringe pattern in those shapes where a quantitative analysis is not afforded.

While there are several excellent rigorous treatments of elastic theory, the study of one of these works requires more time than is usually available to the designer. Moreover many commercial engineers have not had the time to provide themselves with the knowledge of mathematics that these works require.

This article aims to present the logic behind this method of analysis. To this end mathematics has been reduced to a minimum, and so far as possible the text stands independent of the equations. Later in the series of articles the conclusions of a number of important practical problems will be presented. The significance of these conclusions will be discussed,

ELIMINATION of failures and improved performance have been achieved through the application of elastic theory to machines built by the author's company. Actual designs of parts utilizing this theory will be discussed in a series of articles of which this is the introduction. Later articles will present the theory in commercially useful form and will illustrate its application to practical problems

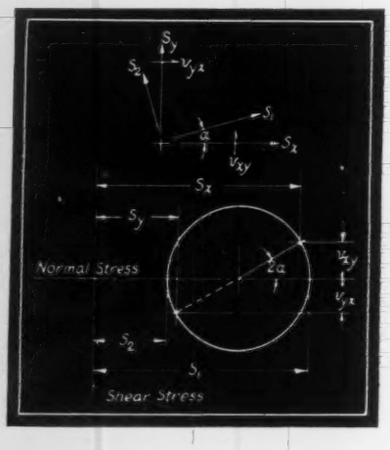


Fig. 2 — Mohr's circle diagram, general condition

both for direct and photoelastic analysis. Where feasible, charts will be presented in a readily usable form.

Using a formula without understanding its development is indefensible and invariably leads to misapplication with disastrous results. A practical problem is seldom exactly as presented in theory and therefore the results will, of necessity, always be an approximation. Unless some knowledge of the development of the equations is in mind, the extent of the approximation cannot be realized. Moreover, many practical problems capable of reduction to theory will pass unrecognized. For these reasons, the theory for each problem will be developed as far as practicable.

Plane stress and plane deformation only will be covered in this series. An example of the former is a thin disk, and of the latter a long roller at sections away from the ends. Many cases of three-dimensional stress may be reduced to plane stress with a superimposed third stress the effect of which may be separately considered. The articles also will not include analysis for deflection, and in order to simplify the mathematics the analysis will exclude body forces, such as the weight of the part itself, etc. Only surface forces will be considered, that is, those applied to the boundary of a body—external or internal boundary. The logic of the development is the same in either case.

Theory Assumes a Perfect Material

Theory is naturally predicated on the assumption of a "perfect" material, that is, one where the linear relation between strain and stress is fully met, where the body recovers its original shape completely on removal of the loads, and where there are no directional properties. The imperfections of actual materials should never be overlooked in applying the conclusions developed upon this premise to an actual problem.

Elastic theory is based upon two principles: First—the distribution of the stress throughout a body is continuous, that is, there is never an *abrupt* change in its value. Mathematically this means that the rate of change in the stress, i. e. the derivative, never becomes infinite. Second—the same assumption for the variation in the strain. These two points are irreducible and must therefore be treated as axiomatic. The first is logical if it be assumed that Newton's third law, action and reaction are equal and opposite, applies to the elements within a body, as well as between two bodies. If the principle were not true, then, at a point of discontinuity, the reaction would not balance the action. The logic of the second principle lies in that, if it were not true, at a point of discontinuity a void would appear when the body was loaded.

It should be noted that the acceptance of these two premises means that elastic theory is the only true analysis, as the conclusions are built up mathematically on these two bases with complete rigor. The value of other methods are to be measured by the degree to which they approximate elastic theory. Later in the series, elemental analysis will be measured with this standard, defining thereby its limitations and its application.

Directional Relations of Stress

For this work there frequently will be *two* independent variables. For example, the stress at a point will depend upon its co-ordinate position, ie., upon the value of both x and y. That is, $S_x = f\ (x, y)$, where S_x is the direct stress in the x direction and $f\ (x, y)$ is some relationship involving x and y. It is apparent then, that the rate of change of S_x must also involve the direction in which this rate is to be measured. Such a concept is included in the partial derivative with respect to x or y, symbolized $\partial S_x/\partial x$ or $\partial S_x/\partial y$.

In the following, a stress normal to the plane on which it is acting will be represented by S, and a stress

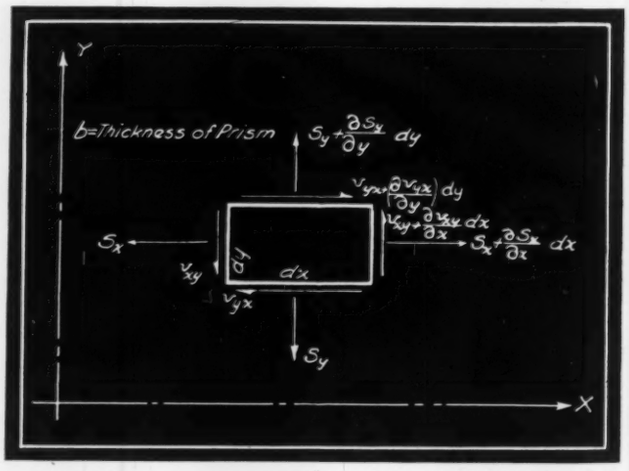


Fig. 3—Stresses acting on the boundaries of an elemental prism under plane stress. Body forces are assumed to be nonexistent for the discussion

parallel to the plane by v. Subscripts will indicate the directions of the normals to the planes on which these stresses act and, for the parallel component, its direction also. An elemental prism subjected to plane stress is shown in *Fig.* 1.

It was demonstrated in the photoelastic series* that $v_{xy} = v_{yx}$, (i.e., horizontal shear equals the vertical) and that the stress at a point in any direction bears a definite relation to the stresses in the X and Y direc-

* MACHINE DESIGN, March, 1940, pages 32 and 33.

tions. Therefore, knowledge of the distribution of S_x, S_y and v_{xy} throughout the body is sufficient for the determination of the stress at any point in any direction. Mohr's circle diagram, *Fig.* 2, illustrates this directional relationship. Shown by S_1 and S_2 are the two principal stresses, and α is the angle of inclination of the S_1 principal stress with the X axis.

The difference in the stress between two points is equal to the rate of change in stress times the distance between the points, provided the rate is constant. If these two points are adjacent, dx the elemental distance between them, and S and S' the stresses at the two points, the above may be expressed mathematically in the case of a variable rate by

$$S' - S = \frac{\delta S}{\delta x}\, dx$$

from the previous definition of the partial derivative. The stresses S and S' are, of course, to be taken in the same direction, not necessarily the X direction. Without the original assumption of a continuous variation in stress, the $\delta S/\delta x$ could at some point become infinite. At such a point the above equation would have no meaning.

Development of General Stress Formulas

With that in mind the stresses acting on the faces of an elemental prism, oriented in the X and Y directions, are presented in *Fig.* 3. Since the prism is in equilibrium, the summation of the forces in any direction equals zero. In the X and Y directions they are

$$\frac{\delta S_x}{\delta x}\, dx(bdy) + \frac{\delta v_{yx}}{\delta y}\, dy(bdx) = O$$

$$\frac{\delta S_y}{\delta y}\, dy(bdx) + \frac{\delta v_{xy}}{\delta x}\, dx(bdy) = O$$

Dividing by $bdxdy$ and substituting v_{xy} for v_{yx}

$$\frac{\delta S_x}{\delta x} + \frac{\delta v_{xy}}{\delta y} = O \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\frac{\delta S_y}{\delta y} + \frac{\delta v_{xy}}{\delta x} = O \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

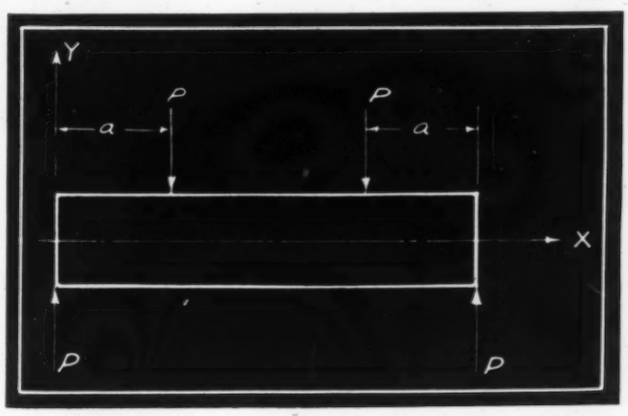


Fig. 4—Simple beam symmetrically loaded. Vertical shear is zero and moment is constant between the loads

Equation (1) states that the rate of increase in S_x in the X direction is balanced by the rate of decrease in the shear in the Y direction. Similarly for S_y in Equation (2). The special case shown in *Fig.* 4 will serve as an illustration. Between the loads, v_{xy} equals zero. Therefore, considering Equation (1), S_x must remain constant in the X direction. Since the moment is constant between the loads this is in agreement with elementary theory. S_y also does not change in the Y direction and since, by elemental theory, it equals zero, this also is in agreement. It should be noted however, that these equations say nothing about the variation of S_x in the Y direction, or S_y in the X.

The concept expressed by Equations (1) and (2) will be familiar to many if presented as another special case. By elemental theory S_x for a beam is given by

$$S_x = -\frac{My}{I}$$

where M is the external moment at the section and I the moment of inertia of the section. The minus sign results from the conventional assumption for the positive direction of moment, clockwise for summation to the left of the section. Differentiating with respect to x, and remembering that $\delta M/\delta x = V$, where V is the

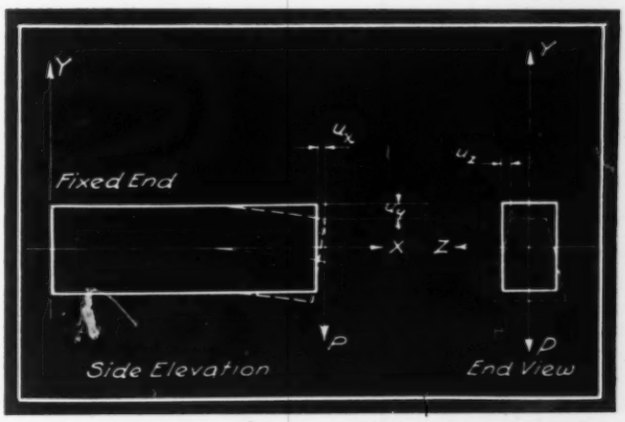


Fig. 5—Strain in a cantilever beam

total vertical shear on the section (positive when the summation of forces to the left of the section is upward), we obtain

$$\frac{\delta S_x}{\delta x} = -\frac{y}{I}\frac{\delta M}{\delta x} = -\frac{Vy}{I}$$

Here I is assumed as constant. Substituting in Equation (1)

$$\frac{\delta v_{xy}}{\delta y} = \frac{Vy}{I}$$

Integrating the above and determining the constant of integration from the condition that $v_{xy} = 0$ at the upper and lower boundaries $y = \pm c$,

$$v_{xy} = -\frac{V}{2I}(c^2 - y^2) = -\frac{VM_s}{I\,b} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where M_s is the statical moment of the area from y to

c about the neutral axis, given by $M_s = \frac{1}{2} b\ (c^2 - y^2)$, and b is the thickness of the beam. Equation (3) is the well known "strength of materials" equation for horizontal shear in a beam.

The above discussion has been directed at the condition of an element entirely within the body. Consideration of an element located with one face in the boundary leads to the "boundary conditions." The stresses at the boundary must be balanced by the forces acting on the boundary. In other words, the stress system must run out into the boundary loads. This condition was discussed in detail in the preceding series.*

Stress differential relations, Equations (1) and (2), and the boundary conditions enunciated in the preceding paragraph, are all that can be drawn from the static conditions of equilibrium. The solution of any body is statically indeterminate, and the remaining conditions must be drawn from the strain relationships.

Evaluating Components of Strain

In the preceding discussion, stress differential relations were developed from the first principle of elastic theory. In somewhat the same manner, a differential relation between the strains may be developed from the second principle, " . . . . continuous distribution of the strain." Before this can be done, however, it is necessary to develop a system of representing strain components. This will be presented in three dimensions first, reducing to two dimensions later.

If x represents the co-ordinate of a point before loading and x' its location after loading, the total strain of this point in the X direction would be given by $x' - x$. Let u_x represent this quantity. Similarly, $u_y = y' - y$ and $u_z = z' - z$. Then the total movement of a

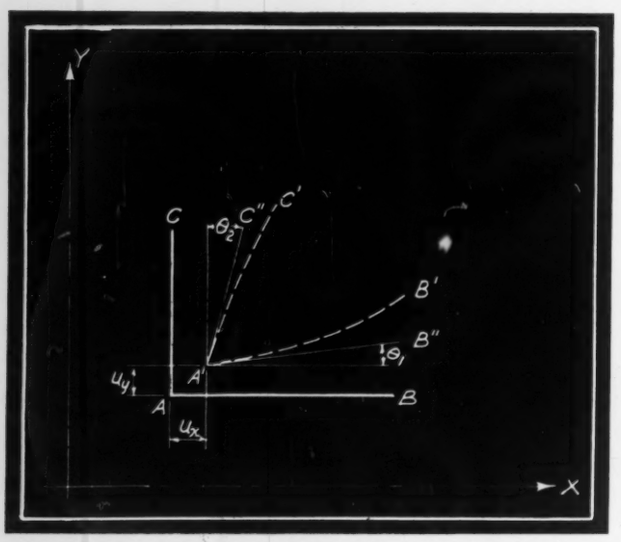


Fig. 6—Angular distortion at a point in a strained body

point is given by its three strain components, u_x, u_y, and u_z. The co-ordinates of a strained point (x, y, z) before loading, then, are given by $x + u_x$, $y + u_y$, $z + u_z$.

* MACHINE DESIGN, Page 41, April, 1940.

Illustrated in *Fig.* 5 is a beam bent in the XY plane. Indicated in the elevation are u_x and u_y for one corner of the beam. Due to the lateral contraction there will also be a u_z for this corner, as shown in the end view. This will be discussed later in more detail.

It is apparent that u_x, in the general case of strain, will vary from point to point. In *Fig.* 5, for example, the left end is fixed and therefore u_x here equals zero over the entire cross section. It increases at a variable rate to a maximum at the right-hand end. From the definition of the derivative previously given, this rate, at any point, is given by the partial derivative with respect to x.

Also u_x will vary in a transverse direction, and the rate of this variation will be given by the partial derivative of u_x with respect to y. In this case u_x is constant with z, but, in the general case, it and its rate would vary in the Z direction too. Similarly with u_y and u_z.

The rate of strain in the direction of the component of strain is known as the "unit strain." It will be denoted by ϵ with subscript denoting the direction. Accordingly,

$$\epsilon_x = \frac{\partial u_x}{\partial x} \qquad \epsilon_y = \frac{\partial u_y}{\partial y} \qquad \epsilon_z = \frac{\partial u_z}{\partial z} \qquad \ldots\ldots\ldots (4)$$

In a bar under simple tension the rate of strain is constant and therefore equals the average. That is, if u is the total extension over the length $x = l$ of the bar, the rate of strain is u/l; or

$$\epsilon_x = \frac{\partial u_x}{\partial x} = \frac{u}{l}$$

The preceding covers the movement of various points when the body is loaded. In the general case of strain there is also an angular change which will vary from point to point.

Distortion of a right angle in the general condition of strain is illustrated in *Fig.* 6. AB and AC are the two sides of the right angle, straight and parallel to the X and Y co-ordinate axes before bending. In straining the point A is moved to A'. B is likewise moved to B' and the straight line AB becomes the dotted curved line $A'B'$. Similarly, AC moves to the dotted position $A'C'$. $A'B''$ is drawn tangent to $A'B'$ at A' and makes the angle θ_1 with AB, as shown. Similarly for θ_2.

Since the value of y for AB is constant with x, the variation in y for the curve $A'B'$ is due solely to the variation in the value of u_y in the X direction. That is, if u_y were constant, $A'B'$ would be a straight line parallel to AB. The rate of the variation in the value of y for $A'B'$, then, is given by the derivative of u_y with regard to x. Since the slope of the tangent to the curve is also a measure of this rate we may write

$$\tan \theta_1 = \frac{\partial u_y}{\partial x}$$

Since the strains and distortions in engineering structures are small, θ_1 will be a small angle. Therefore its

measure (in radians) will approximate closely the value of its tangent. Making this substitution gives

$$\theta_1 = \frac{\partial u_y}{\partial x}$$

In a similar way the value of θ_2 is developed as

$$\theta_2 = \frac{\partial u_x}{\partial y}$$

Now the total change in the original right angle CAB is equal to the sum of θ_1 and θ_2. Denoting this angular change by γ with subscripts to indicate the co-ordinate axes to which the original right angle was parallel

$$\gamma_{xy} = \theta_2 + \theta_1 = \frac{\partial u_x}{\partial y} + \frac{\partial u_y}{\partial x} \quad \ldots\ldots (5)$$

In a similar way the angular change parallel to the other two co-ordinate planes is developed as,

$$\gamma_{xz} = \frac{\partial u_x}{\partial z} + \frac{\partial u_z}{\partial x} \quad \ldots\ldots (6)$$

$$\gamma_{yz} = \frac{\partial u_y}{\partial z} + \frac{\partial u_z}{\partial y} \quad \ldots\ldots (7)$$

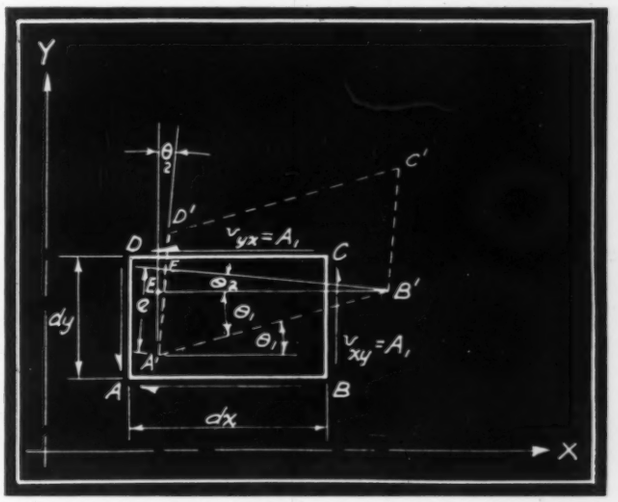


Fig. 7—Elemental prism under uniform pure shear

The angular changes given by Equations (5), (6) and (7) are made up of the sum of two rates and are due to the shear stress, therefore γ is termed the "unit shear strain."

In the case of a body subjected to a uniform shear v_{xy}, with S_x and $S_y = 0$, lines parallel to the co-ordinate axis and originally straight will remain straight, changing only in angle. The condition of a strained elemental prism in this case is shown in the dotted position $A'B'C'D'$ in *Fig.* 7. In the construction, $B'E$ is drawn perpendicular to AD and $B'F$ perpendicular to $A'D'$. From this construction it is apparent that angle $A'B'F = \gamma_{xy}$. Now the movement of BC relative to AD is the distance e, and the rate of this movement e/dx. This is the usual conception of shear strain or "detrusion" presented in strength of materials. Making the approximation again, that the tangent equals the angle,

$$\frac{e}{dx} = \tan \gamma_{xy} = \gamma_{xy}$$

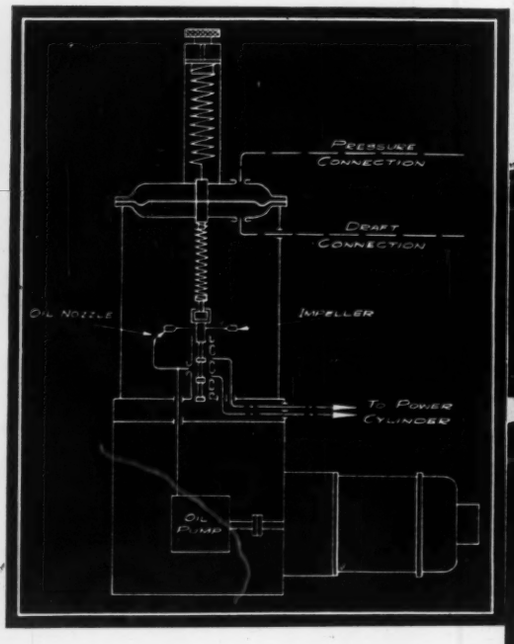
It is apparent that we may think of the unit shear strain, γ_{xy} as being the rate of sliding of one plane on another, or as the total angular change at a point, as previously described. The latter conception will be used in the development to follow.

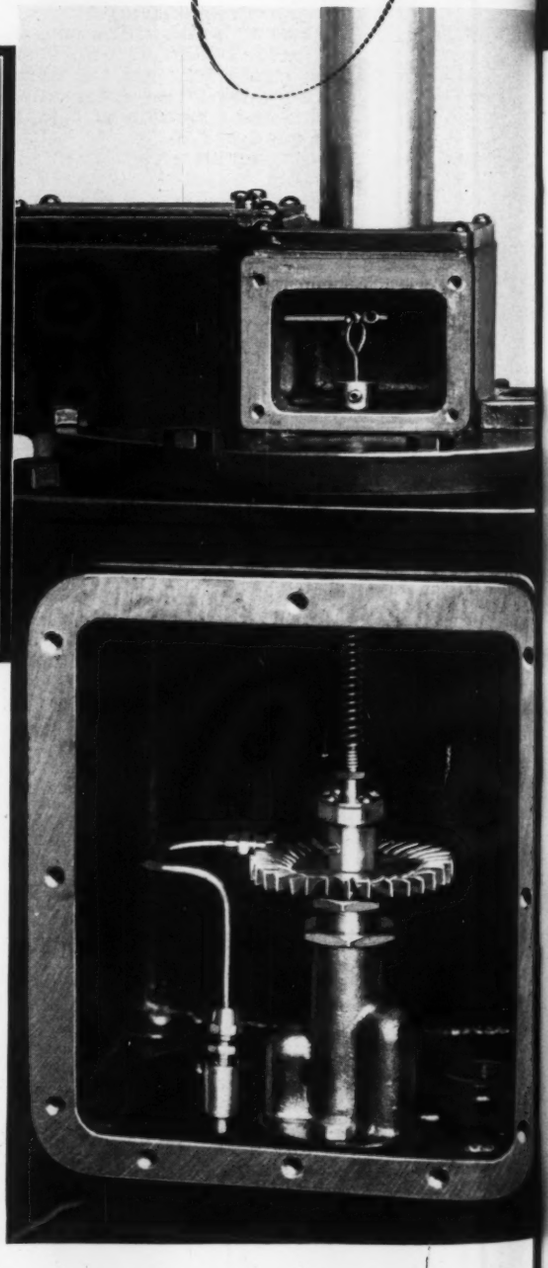
Nomenclature

α	Inclination of the principal directions measured from the X axis to the direction of S_1.
$\gamma_{xy}, \gamma_{xz}, \gamma_{yz}$	Unit shear strain in the XY, XZ, or YZ planes respectively, and parallel to the coordinate axes.
$\epsilon_x, \epsilon_y, \epsilon_z$	Unit direct strain in the X, Y, or Z direction respectively.
λ	Poisson's Ratio. Known also as the "factor of lateral contraction."
$\phi = \phi(x, y)$	The stress function. A parameter between the stress differential relations and the condition of compatibility of Equation (28).
A	Cross section area.
B	$B = l/d$.
E	Young's modulus of elasticity.
G	Shear modulus of elasticity.
H	Calibration value of photoelastic model material, in pounds per inch per fringe.
I	Moment of inertia of cross section.
M	Resultant external bending moment on a section (Positive when the summation to the left of the section is clockwise).
M_x	External moment at the section x.
M_s	Statical moment of area of cross section from y to c.
P	Total applied load. Usually taken as concentrated.
Q	The principal stress difference, $(S_1 - S_2)$.
S_1	A principal stress, usually taken as the largest algebraically.
S_2	The other principal stress.
S_x, S_y	Normal components of stress in the X or Y direction, respectively.
V	Resultant external shear on a section (Positive when the summation to the left of the section is up).
V_x	External shear at the section x.
W	Total applied distributed load.
b	Thickness, in a direction perpendicular to the plane of stress.
c	Distance from the centerline of section to the outer surface.
d	Depth of a beam.
dx, dy	Elemental lengths in the X or Y directions, respectively.
e	Shear "detrusion". Also eccentricity of applied load.
l	Span of a beam.
n	Fringe order.
q	Intensity of a continuously distributed load applied normally to the boundary.
u_x, u_y, u_z	Components of strain in the X, Y, or Z directions, respectively.
v	Intensity of a continuously distributed load applied parallel to the boundary.
v_m	The maximum shear stress obtaining in any direction at a given point.
v_{xy}, v_{yx}	Shearing components of stress, on the plane on which S_x or S_y are acting, respectively.
y_1	$y_1 = y/c$.

Scanning the Field

FOR IDEAS

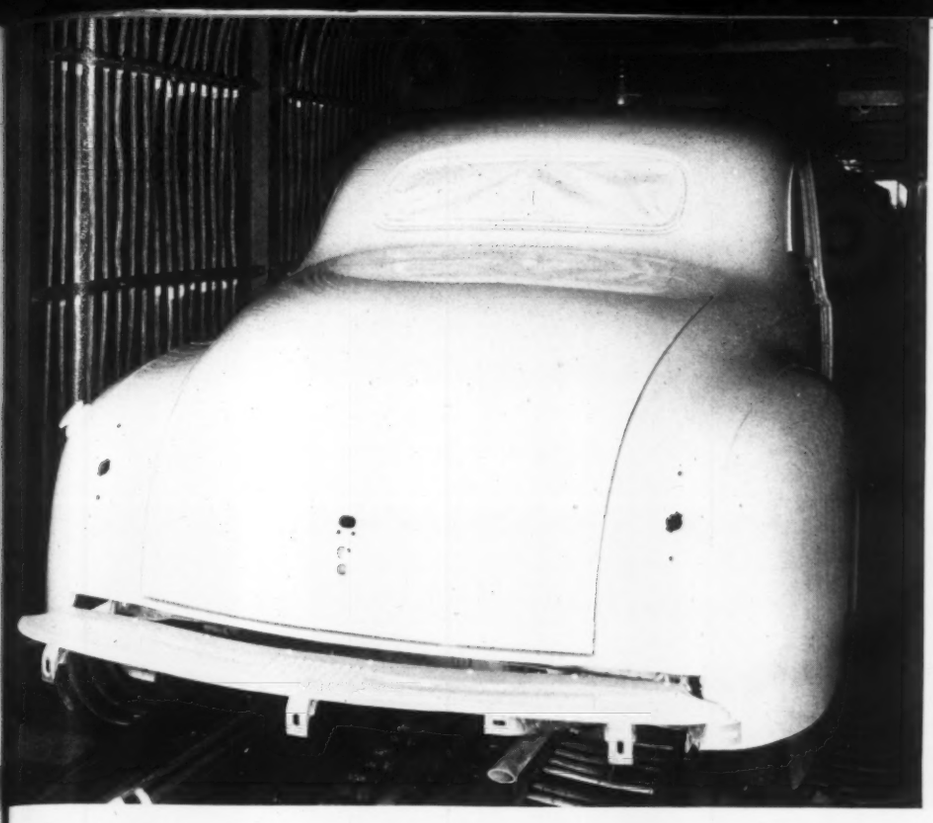




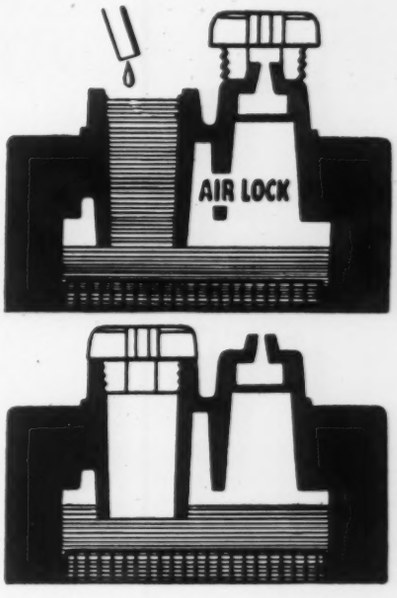
Sensitive operation of parts requiring quick and accurate response to an initiating action can be obtained in various ways. Careful balancing of parts, reduction of inertia, use of anti-friction bearings or booster devices are typical. Another method of obtaining sensitive operation is shown in the valve designed by the Hagan Corp. Quick response to control is obtained through removing the static friction load on the valve stem.

Diaphragm controlled, the stem is operated from the lower side of the diaphragm, as shown in the schematic drawing. Oil at approximately 80 pounds per square inch is supplied to the valve and, at the same time, a bypass stream is directed against an impeller attached to the valve stem. This causes constant rotation of the stem within the ported sleeve and allows utilization of the principle that force required to set up motion is greater than that needed to continue it.

Thus every deflection of the diaphragm, however small, is transmitted instantly and accurately to the valve, causing supply and drain ports to be opened and permitting oil under pressure to be transmitted to a power cylinder.



Induction heating offers possibilities for reducing production bottlenecks caused by finishing and drying operations. An oven for this type of heating is illustrated at left for drying the enamel on a Chrysler body at a temperature of 240 degrees Fahr. Loops of wire around the inside of the oven constitute a big induction coil through which high frequency current flows. Heat produced by induction proceeds from the center of the metal outward, drying the paint next the metal first. This produces a hard, long-lived finish at a high rate of speed.



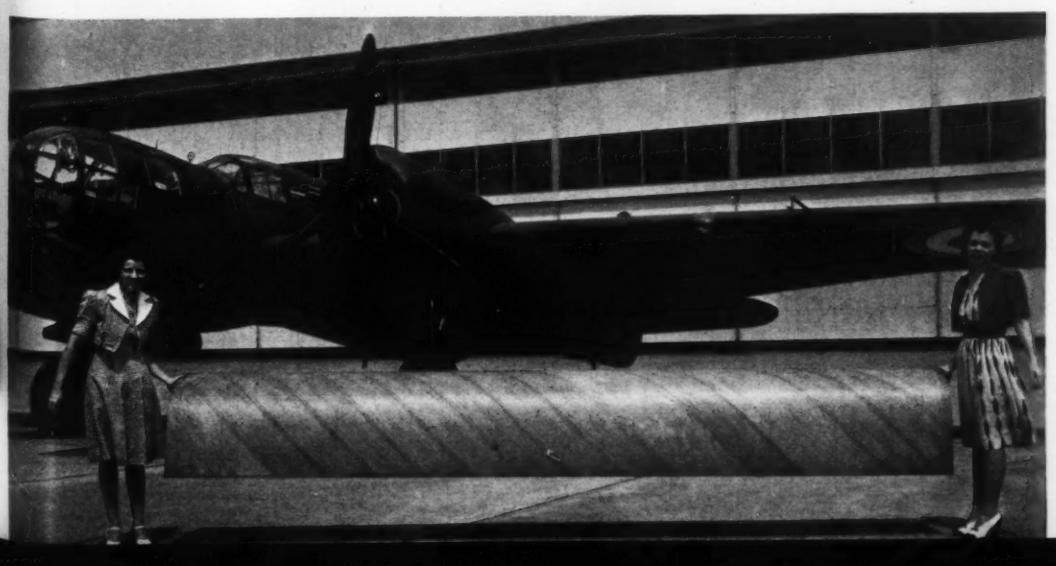
Accurate filling without danger of spillage due to overfilling and without time usually required for checking is provided in the effective safety-fill shown schematically at right for Willard batteries. Particularly useful when refilling is frequent or when corrosion might result from acid attack, this design utilizes the principle of air-lock to control liquid levels.

As shown, cap is placed over a vent to form an air lock in the expansion chamber. Filling with liquid seals off the chamber by an extended neck around the filling hole. Replacing the cap frees the trap and the liquid falls to its correct level. Utilizing cap for dual purpose also prevents loss or damage.

Plastic plywood applications have extensive possibilities with respect to aircraft because of their capability for high production rates, high strength-weight ratios and flexibility in design. An aircraft application is shown below in the illustration of a bomb bay door designed by the Glenn L. Martin Co.

Door is essentially a hollow box of plywood covers and poplar framing weighing approximately fifty pounds. Covers are $\frac{1}{8}$-inch plywood with mahogany faces and poplar core bonded with phenol formaldehyde. Ribs are fifteen laminations of $\frac{1}{8}$-inch poplar with urea formaldehyde adhesive. End ribs and hinge rail are ash veneer.

Tests at 150 pounds per square inch loading showed no perceptible buckling. Measured deflection was approximately one-third that of the equivalent metal door of the same weight.



Pneumatics Provides Finger-Tip Control

By Fred L. White
Chief Engineer
The Osgood Co.

IN ADDITION to providing ease of operation, built-in pneumatic controls simplify design by eliminating involved linkages necessary for manual control. Further, use of compressed air metering control valves introduces a cushioning action to protect the machine from shock loads which might otherwise result from jamming engagement of gears or positive clutches.

Utilizing pneumatic controls to obtain these advantages, the illustrated power shovel was designed to permit the following operator-directed functions: (1) Independent driving of either of the tractor treads; (2) rotation of the cab in either direction on the tractor carriage; (3) raising or lowering of the boom about its hinge pin; (4) raising or lowering the shovel supporting arm by rotation about its hinge bearing; and (5) advance or retraction of the shovel supporting arm by means of a pinion gear which drives a rack fastened to the arm.

Metering valves by which all these operations are controlled may be seen in the illustration. In large high-powered units, it should be pointed out, some form of auxiliary control mechanism is essential; in smaller units operator fatigue is greatly reduced by their use.

To aid in discussing how the controls are designed into the machine, *Fig.* 1 shows a plan view of the complete drive. The main driveshaft is chain driven from a 132-horsepower diesel engine. To swing or rotate the cab in either direction relative to the tractor chassis, the shaft carries two disk type clutches, each of which when engaged drives its own bevel gear. To engage each of these clutches an air cylinder is used, the piston rod of which operates a forked lever sliding a cam sleeve on the driveshaft.

Cab Is Swung Through Bevel Gears

A third bevel gear engages both of the clutch-driven bevels and drives the vertical shaft. Swing of the cab is effected by a spur pinion carried on the other end of this shaft which mates with the swing gear mounted in the swing shaft in *Fig.* 2. A swing pinion mounted on the end of this shaft engages a ring gear integral

with the tractor chassis. A three-way metering control valve supplies air to each of the cylinders through metal tubing, thus permitting all the mechanism to be centrally located and adaptable to remote control without mechanical links or levers.

Drive for the tractor treads is also taken off the swingshaft shown in *Fig.* 2. The swing gear is in permanent engagement with an intermediate travel gear mounted on an intermediate shaft. Floating on this shaft is a travel pinion with jaw clutch teeth formed on its face which mate with similar teeth on the face of the intermediate travel gear. When this positive clutch is engaged the travel gear is driven through the pinion and the travel bevel transmits the drive to the tractor treads. Two positive clutches on the tread-drive sprockets permit one or the other or both of the treads to be driven.

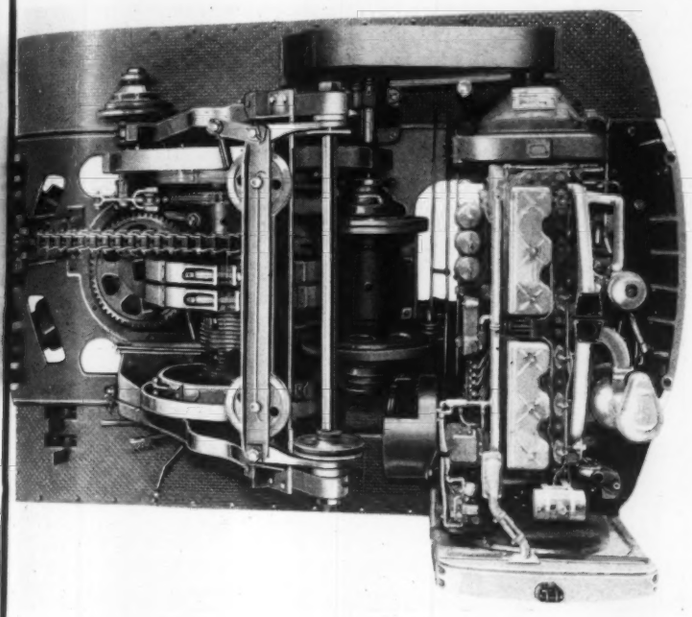


Fig. 1—Plan view of complete shovel drive mechanism shows diesel power plant, disk, band clutches and brakes

Fig. 2—Swing mechanism and tractor tread drive assembly is controlled by two manually operated positive clutches

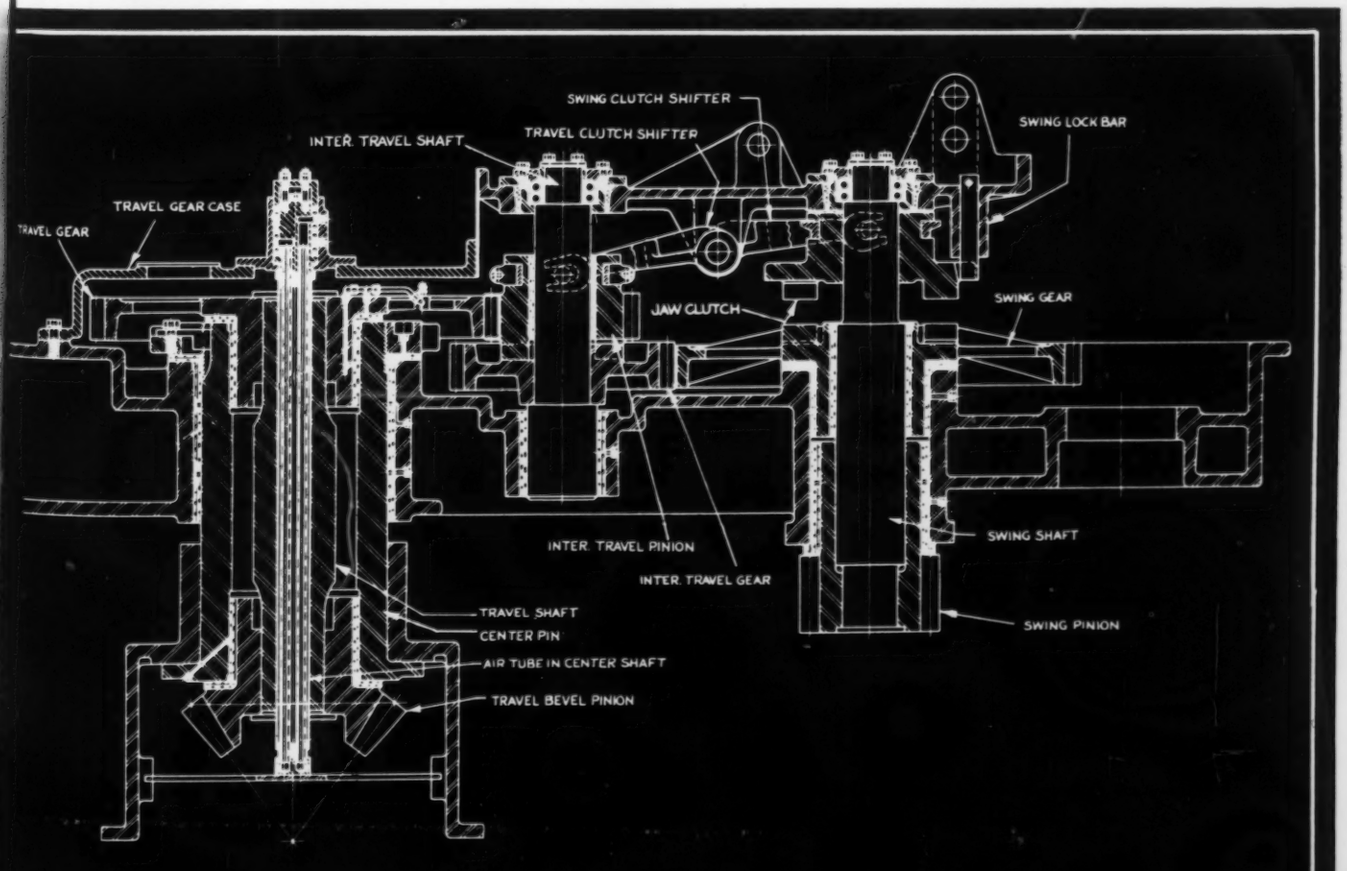
Operation of both the boom and the shovel arm is effected through a hoist pinion mounted on the main driveshaft as shown in *Fig.* 3. This gear drives the hoist gear which is rigidly mounted on the drumshaft, see *Fig.* 4. On the opposite end of this shaft a driver is mounted. This driver and the hoist gear each carry a friction band for a clutch drum which in one case is integral with the shovel lifting winch and in the other with the "crowding" sprocket. When the clutches are not engaged both the winch and sprocket are free on the drumshaft.

Air Cylinder Rotates with Clutch Drum

These clutches are pneumatically operated, compressed air being supplied to the operating cylinder by means of a swivel joint connected to an air passage in and concentric with the drumshaft. As *Fig.* 4 shows, the air cylinder rotates continuously with the drumshaft and operates a crank arm which applies tension to the clutch bands by means of an eccentric.

In the center of the drumshaft are two manually operated brake drums, bands for which are anchored to the housing. These brakes are used to hold the shovel in the position to which either the winch or crowding sprocket moves it. They are manually operated so that in the event of air failure the operator is able to prevent movement of the entire shovel assembly.

If it is desired to retract the shovel by means of its



driving rack and pinion an auxiliary sprocket is used, mounted parallel to the crowding sprocket in *Fig.* 4. In order to effect the necessary reversal of the crowding sprocket, the hoist gear drives a reversing gear mounted on a jackshaft. When reversal is desired a pneumatically operated disk clutch also mounted on this jackshaft is engaged, transmitting the drive back to the crowding sprocket through a chain on the auxiliary sprocket.

Thus the shovel may be crowded or retracted by means of driving, through a rack and pinion, the shovel supporting arm, or it may be raised and lowered (rotated about the hinge pin on the supporting arm) by means of a wire rope wound on the hoisting winch.

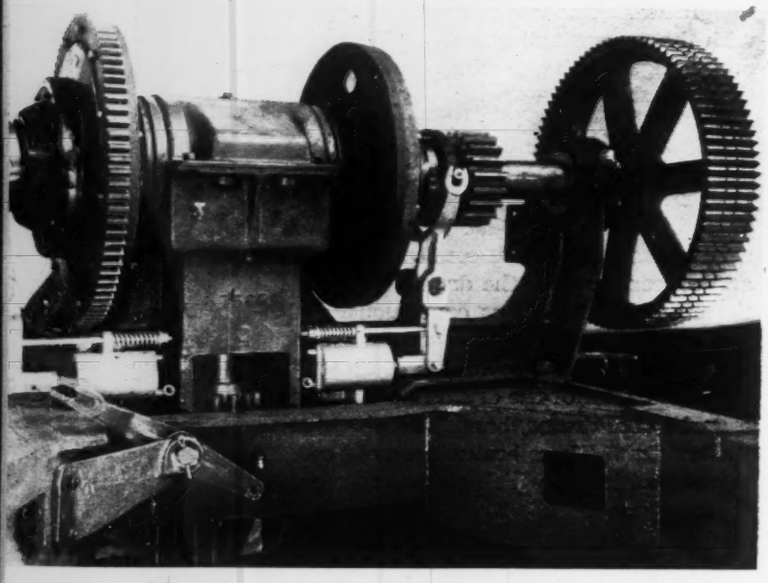


Fig. 3—Main drive assembly controls every operation and is permanently geared to power plant. Air cylinders may be seen which operate disk clutches

Fig. 4—End view of drum shaft shows method by which the hand clutches are operated by pneumatic cylinders

Since all these operations are pneumatically controlled, operator effort is reduced to a minimum.

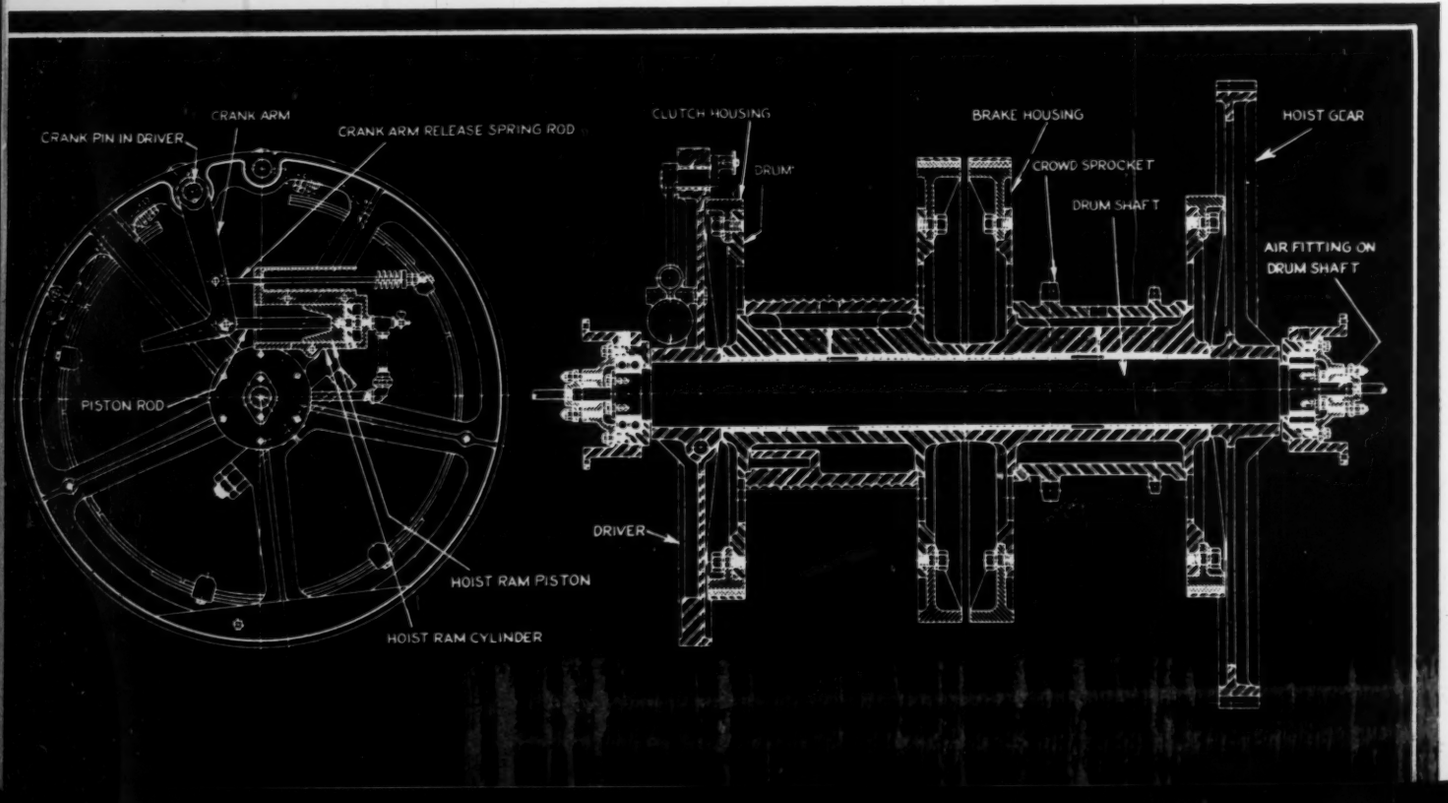
The remaining operation, raising or lowering of the boom, is accomplished by the mechanism shown in the lower right section of *Fig.* 1. The boom hoist gear mounted on the driven housing of the left-hand disk clutch in *Fig.* 3 engages the boom hoist gear. A drum fastened to a worm wheel is driven by a worm on this gearshaft, engagement being effected by a positive clutch operating on the trunnion collar. This clutch is hand-controlled to safeguard the boom hoist cables from overload which might result from operator inattention. Engagement of this clutch raises the boom and a brake drum is provided for holding the boom in any position. In lowering the boom, the clutch is disengaged and the boom falls under its own weight.

Receiver Compensates for Leakage

A small amount of leakage is inevitable in involved pneumatic systems. However, the cost of compressing the little air needed for operating machine controls is low, hence the cost of leakage air is negligible. A small air receiver installed in the pneumatic circuit will usually suffice to compensate for ordinary leakage during many days of equipment idleness.

Utilization of a compressible medium such as air to operate the controls provides, as previously indicated, the further advantage of eliminating shock engagement of gears and clutches. This is a vital factor in the long life of satisfactory service under severe operating conditions such as is expected of the power shovel discussed in this article.

It is evident from this discussion that in machines where a large number of different operations must be under virtual finger-tip control of only one man, the advantages of pneumatic operation more than justify the moderately expensive parts required. A compressor, control valves, cylinders and connecting pipe lines are definitely preferable to the alternative array of levers, connecting rods and cranks.



Selecting Special Motors

Part II—Small Reversing Motors

By W. M. Yogerst and C. A. Rall
Bodine Electric Co.

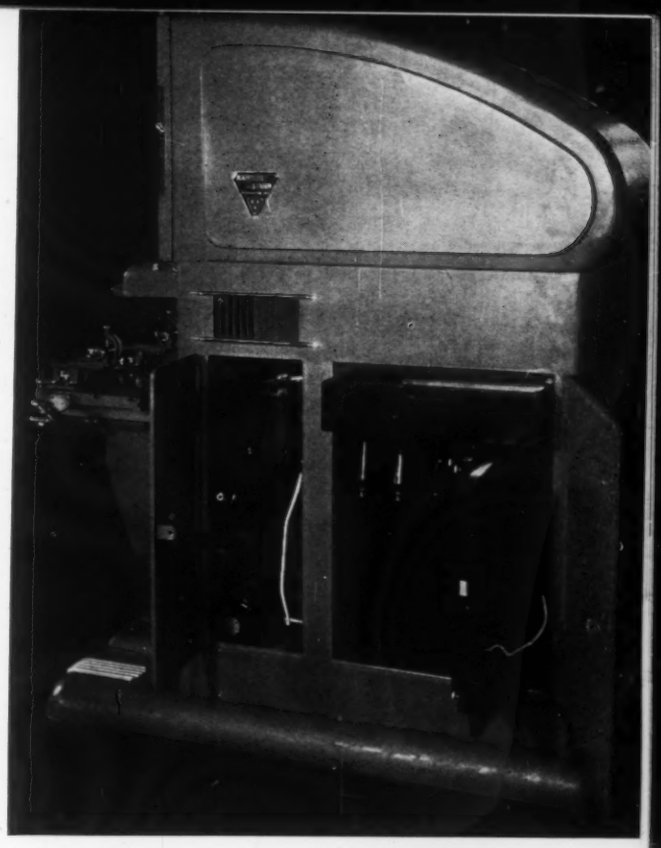
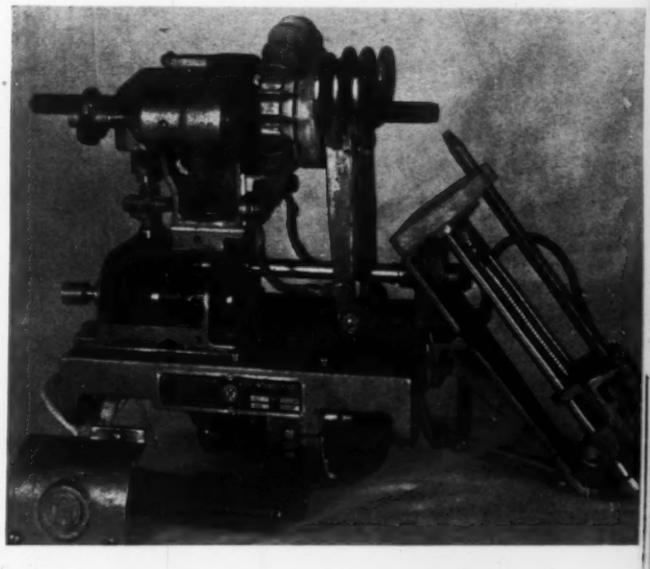


Fig. 1—Above—Series-wound, split-field, three-lead motor drives the work table of contour projector. Instant reversal and wide range of speed control are required

Fig. 2—Below—Speed regulation is critical and instant reversibility essential for motor driving electrodes in automatic arc lamp. Motor is connected in a wheatstone bridge circuit



TRENDS in design toward the increasing use of individual drives have eliminated devices used in other forms of drive, as well as intricate interlocking mechanisms. Further, the employment of reversing motors obviates mechanical reversing mechanisms, providing a reliable, quiet, efficient, flexible and long-lived drive.

To keep this discussion within reasonable limits it will be confined to the treatment of the most commonly used types of reversing fractional horsepower motors. Small units of this type are used on machines where individual operations can be performed by individual motors; for example, milling machines and thread grinders. Many applications require fast reversing as in the contour projector shown in *Fig.* 1. In some drives, speed regulation is critical like in the arc lamp unit, *Fig.* 2. Among other devices which employ small reversing motors advantageously are grinding wheel dressers, variable ratio drives, field rheostats, door operators, scale devices, and telescope drives.

Small reversing motors are generally divided into two groups. One includes motors which can be reversed only while at rest. The other comprises those which can be reversed during rotation. In the latter, when the reversing switch is thrown into the reverse position the motor changes quickly from full speed in one direction to full speed in the other.

Types of motors in the first group can be reversed only after rotation ceases because the starting winding, which gives direction to the rotor, has been disconnected from the line by an internal centrifugal switch. Motors in the second group can be reversed while rotating by changing the relative polarity between the windings, thus reversing the direction of rotation. These motors are instantly reversible from full speed forward to full speed reverse, because they have no centrifugal starting switch. Characteristics of motors in both the first and second group are included in the accompanying table and are discussed fully in the following paragraphs.

Motors which are reversible only while at rest do

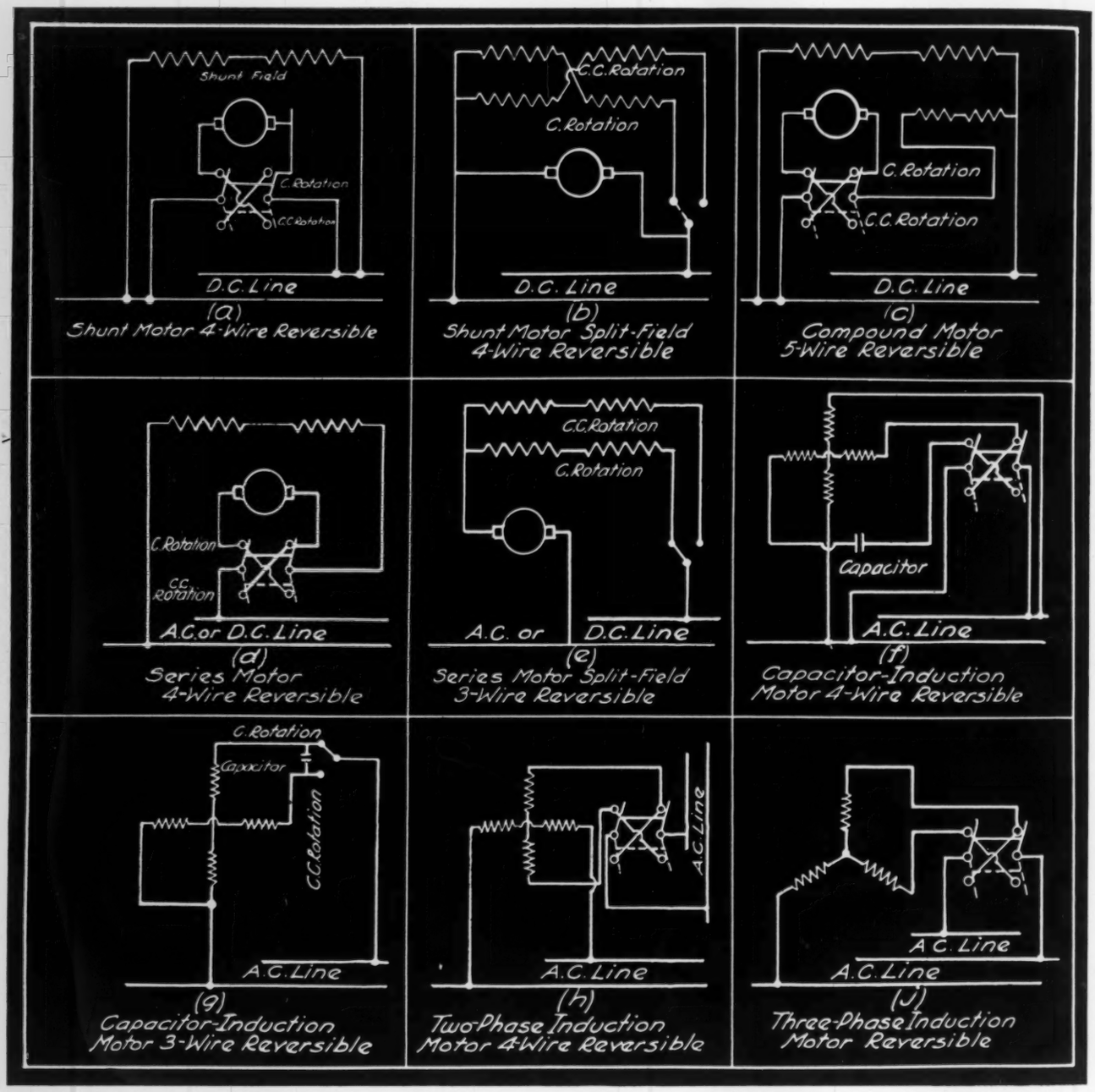


Fig. 3—Schematic wiring diagrams for motors that are instantly reversible. Such motors do not depend on a centrifugal switch in starting windings and therefore may be reversed while running

not have their running characteristics affected by their reversing characteristics. Neither are the running characteristics altered when a capacitor is connected in series with the starting winding to increase the starting torque. All motors reversible during rotation, however, have their running characteristics affected by their reversing characteristics. Some types are subject to greater change than others. In the following will be compared the effects on the running performance of the various types of motors due to altering their reversing characteristics.

SHUNT-WOUND MOTORS: The rotation of a shunt-wound motor is reversed by reversing the current through either the shunt field or the armature. The armature current is usually reversed because this reverses the flow of current through the brushes and prolongs their life. Rate of brush wear is affected by electrolytic action, causing one brush to wear down more rapidly than the other. Reversing the current at regular intervals equalizes the rate of wear between them. Shunt-wound motors have four terminal leads, two from the field and two from the armature. Reversing is accomplished by means of a double-pole double-throw switch, as shown in the diagram of connections, *Fig. 3a*.

Specially designed shunt-wound motors for quick reversal and rapid acceleration have certain limitations imposed on their running characteristics. For instance, a strong shunt field aids reversing and starting, but reduces the running speed. Therefore, these specially designed motors generally run at speeds not exceeding 2000 revolutions per minute.

Skewed-slot armatures also improve the reversing

torque of shunt-wound motors. The greater the angle of skew the quicker the reversal but the poorer the speed regulation. A relatively small air gap improves running efficiency, causing smooth performance and low temperature rise. However, where quick reversing is a prime consideration in the motor design, a relatively larger air gap is used at the sacrifice of these features.

Most fractional horsepower shunt-wound motors are of two-pole design because space limitations do not permit the use of four, six, or more poles. The cost, too, would be excessive. Shunt-wound motors having more than the conventional two poles generally have good starting and reversing characteristics.

An even number of armature slots is used in some shunt-wound motors. This symmetrical arrangement saves winding time, but an uneven number of slots enhances the reversing characteristics. *Fig.* 4 shows characteristic curves for a shunt-wound motor. It will be noted that speed drops off more rapidly with increased load where the motor has been designed especially for quick reversals.

Reversing Inferior with Split-Field Winding

A split-field shunt winding can be used where only a single-pole double-throw switch can be accommodated. As shown in *Fig.* 3*b*, the armature is connected directly across the line, while either portion of the field is connected through the switch to the line, depending on which direction of rotation is wanted. The switch should not have an "off" position, because the armature would burn out if left across the line by itself indefinitely. Since only half the shunt field is used at one time the reversing characteristics are inferior to those of the conventional type of shunt-wound motor. Commutation and brush life also are more adversely affected.

COMPOUND-WOUND MOTORS: The rotation of a compound-wound motor is reversed by reversing the current through its armature. For this a double-pole double-throw switch is required, see *Fig.* 3*c*.

A compound-wound motor generally has better reversing characteristics than a shunt-wound motor, because the series part of the field winding increases the field strength during the reversing period. Field

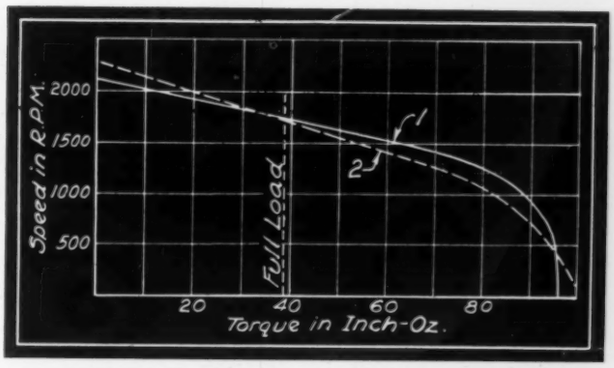


Fig. 4—Speed-torque curve of a 1/15-horsepower shunt motor. Curve 1 shows a motor for ordinary reversing characteristics, while Curve 2 shows the best reversing characteristics obtainable

strength, armature skew, air gap, and number of poles affect both reversing and normal running characteristics in the same manner as in the shunt-wound motor. Increasing the proportion of series to shunt-field ampere-turns increases the reversing torque but impairs speed regulation.

SERIES-WOUND MOTORS: The direction of rotation of the conventional type of series-wound motor is changed by reversing the current through either the field or the armature. A double-pole double-throw switch is utilized as shown in *Fig.* 3*d*. Here the armature current is reversed.

Like the shunt-wound and the compound-wound motors, the reversing characteristics of the series-wound motor are aided by the use of a strong field, skewed-slot armature, and relatively large air gap. Other aids are greater number of poles (if practical), and greater numbers of armature slots and coils.

The ratio of field to armature ampere turns affects the reversing characteristics of a series-wound motor. A low ratio aids reversing, but only at the expense of commutation, brush life, and speed regulation. The design of small motors is such that the brush position with relation to the field poles is fixed, and cannot be adjusted. Therefore, to produce the same effect for any given motor winding, the commutator is shifted, giving a certain lead between each commutator bar and its respective armature slot. This so-called commutator lead is always given with the direction of rota-

Features of Fractional Horsepower Reversing Motors

	Induction Type Reversing Motor								Brush Type Reversing Motor				
	Split Phase		Capacitor Start & Run				Multiphase		Shunt Motor		Compound Motor	Series Motor	
			Non-Synch.		Synch.								
Fractional Horsepower Motors From 1/2000 HP To 1/4 HP	Non-Synch.	Synch.	4-Lead Rev.	3-Lead Rev.	4-Lead Rev.	3-Lead Rev.	Non-Synch.	Synch.	Full-Field	Split-Field	5-Lead Reversible	4-Lead Rev.	3-Lead Rev.
Suitable for reversing at rest only	x	x											
Suitable for reversing during rotation or at rest			x	x	x	x	x	x	x	x	x	x	x
Double-pole double-throw switch required	x	x	x		x		x	x	x		x	x	
Single-pole double-throw switch sufficient				x		x				x			x
Running characteristics slightly affected by best obtainable instantaneous reversing characteristics			x	x	x		x	x	x		x	x	
Running characteristics greatly affected by best obtainable instantaneous reversing characteristics						x				x			x

tion for unidirectional motors. It improves efficiency as well as commutation.

Unfortunately no commutator lead can be given a reversible series-wound motor, because it cannot be changed once it is established for a given direction of rotation. Good commutation is sacrificed, therefore, by making a compromise. The commutator lead must be neutral, so that it favors either direction of rotation equally. Consequently brush life, high efficiency, and low temperature rise are less favorable than in unidirectional motor.

Speed-torque curves for unidirectional series-wound motors are much steeper than those for shunt-wound or compound-wound motors. This is an inherent characteristic of any series-wound motor. Likewise the speed-torque curve of a reversible series wound motor is still steeper. See *Fig.* 5.

Variable Resistor Controls Speed

Speed of a series-wound motor is often regulated by connecting a variable resistor in series with it. This simple method of speed control is adaptable to applications where little starting torque is required, such as fans and blowers. During the starting period the motor draws more current from the line. This increased current flowing through the resistor causes a relatively large voltage drop across it, leaving the voltage reduced considerably across the motor terminals. Under this condition the motor develops little starting torque. A reversing series-wound motor is more adversely affected than a unidirectional motor.

A series-wound motor is much more adaptable to reversing by means of a single-pole double-throw switch than is a shunt-wound motor. Instead of employing all of the field turns at one time as in a unidirectional motor or a full-field reversible motor, the field winding is split into two parts of opposite polarities. One is used at a time in series with the armature for either one of the rotations. Poorer reversing characteristics are obtained than with the full-field reversible motor because of the fewer field turns in use at one time. The running characteristics also are more adversely affected for the same reason. Brush life is also poorer in the split-field reversible motor due to the lower ratio of field to armature ampere-turns.

While the full-field, series-wound, reversible motor has four terminal leads, the split-field reversible motor has only three, as indicated in *Fig.* 3*e*.

CAPACITOR-INDUCTION MOTORS: Windings for this type of motor, resemble those of a two-phase motor. Consisting of two independent windings, each is displaced ninety electrical degrees from the other. This motor has four terminals leads, two from each winding. The direction of rotation is reversed by reversing the current through either winding by means of a double-pole double-throw switch, *Fig.* 3*f*.

Capacitor-induction motors have many advantages over other types of reversing motors. No "commutator lead" or "brush life" consideration is involved in obtaining the ultimate in quick reversing characteristics. Were it not for cost and size of capacitor occasionally required for exceptionally good reversing characteristics, this type of motor would cover a field of application still wider than its present diversified field.

One of the two windings of the capacitor-induction motor, called the main winding, is connected directly across the line, and it usually carries the burden of the load. The other, called the capacitor winding, is connected to the line in series with a capacitor. Function of this winding is primarily to start and reverse the motor, but it also carries a portion of the load during normal running. Ordinarily the amount of copper used is divided equally between the main and capacitor windings. For exceptionally quick reversal, efficiency is sacrificed somewhat to favor the capacitor winding in division of copper.

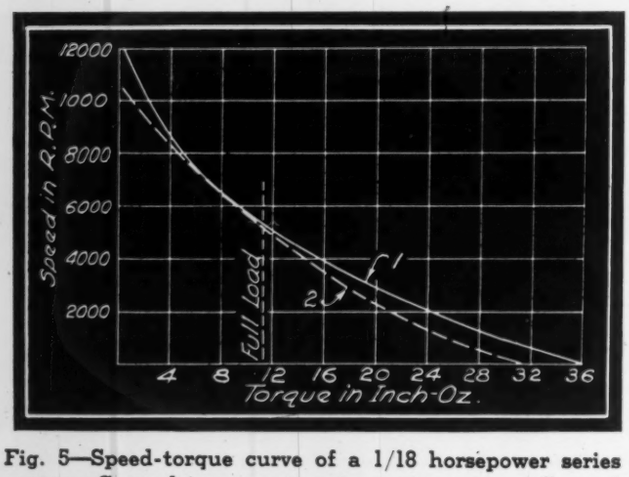


Fig. 5—Speed-torque curve of a 1/18 horsepower series motor. Curve 1 is a nonreversing series motor. Curve 2 is a 4-wire reversible series motor

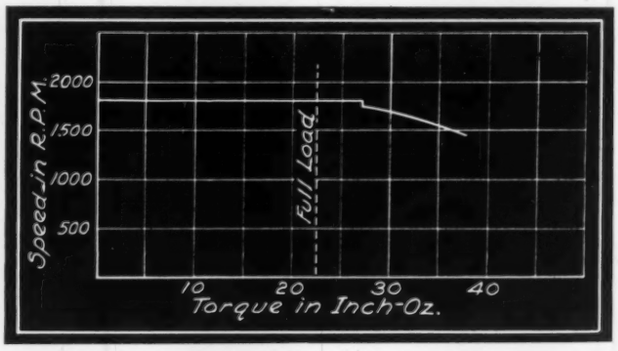


Fig. 6—Speed-torque curve of a 1/25-horsepower capacitor-synchronous-induction motor

Choice of capacitor size affects the starting and reversing characteristics of the capacitor-induction motor to a great extent. The larger the capacitor, the greater the starting and reversing torque, up to a certain critical point. Usually the capacitor size selected is well below this critical point because of space and cost limitations.

Another factor affecting the reversing characteristics of the capacitor-induction motor is the resistance of its squirrel cage rotor. An increase in rotor resistance improves the starting and reversing torque, but decreases the full-load speed and efficiency somewhat.

Speed of capacitor-induction motors, like that of any

induction type of motor, is fixed essentially by the number of poles and the frequency of the power supply. For instance, assuming a frequency of sixty cycles, the synchronous speed of a two-pole motor is 3600 revolutions per minute, while that of a six-pole motor is 1200 revolutions per minute. The reversing characteristics of capacitor induction motors are greatly affected by the number of poles. It is easy to visualize that it takes much more effort to stop and reverse the rotation of a rotor running at 3600 than one running at 1200 revolutions per minute. Therefore, wherever practical, a large number of poles should be selected for motors requiring the ultimate in quick reversibility.

After the motor speed has been fixed by the number of poles it is further influenced to a small extent by the air gap. A small air gap results in high efficiency and little rotor slip. The reversing torque of a capacitor-induction motor is aided by a larger air gap at the sacrifice of efficiency and speed regulation. The speed-torque curve of the capacitor-induction motor with a high resistance rotor, for quick reversing, usually droops slightly more than that of other capacitor-induction motors. That is, the speed drops off to a greater extent with increase in load.

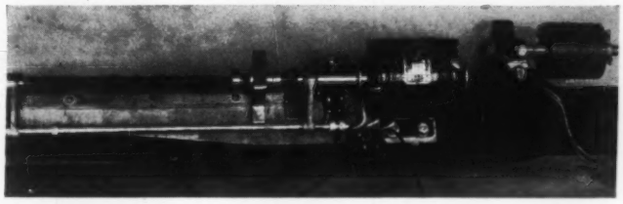


Fig. 7—Instant reversibility and simple switching are provided by this capacitor-induction, three-lead reversing motor for driving weight-positioning mechanism on automatic scale beam

Capacitor-induction motors which employ only three terminal leads also have good reversing characteristics. This motor requires a single-pole double-throw switch, *Fig. 3g*. Like the four-lead motor it has two windings displaced by ninety electrical degrees. Both windings are alike as regards number of turns and size of wire. The functions of both windings are interchangeable. The capacitor is connected in series with one winding for one direction of rotation, and in series with the other for the opposite direction.

Necessity of making both windings in a three-lead capacitor-induction motor exactly alike causes the design of winding and selection of capacitor size to become somewhat difficult. Either winding when employed as the main winding must be strong enough to do its part in carrying the full load at rated speed without over-heating. When used as the capacitor winding it must develop enough torque to contribute its share in starting and reversing. A capacitor value then is chosen large enough to secure good reversing characteristics, but small enough to allow approximately equal distribution of full-load ampere-turns between both windings. In general, a larger capacitor is required for a three-lead motor than for a four-lead motor.

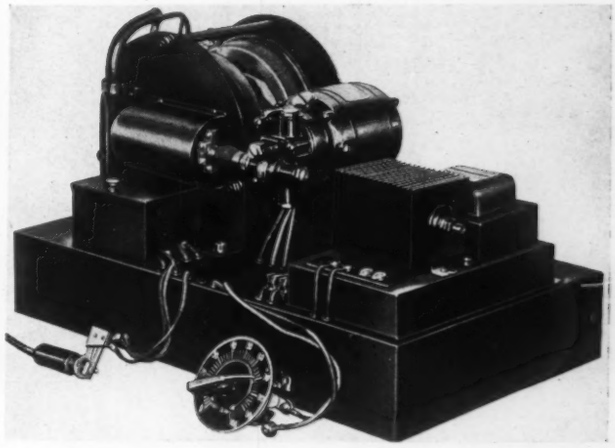


Fig. 8—Speed regulation is not critical for this electric arc crater eliminator, therefore a series-wound, split-field, three-lead motor is used

Three-lead capacitor motors are affected by rotor construction and air gap in the same manner as four-lead motors, but generally to a slightly greater extent. The speed-torque characteristics are practically identical. There is a tendency for slightly more drooping in the case of the three-lead motor, all other factors remaining equal.

Reversing Impairs Characteristics

SYNCHRONOUS-CAPACITOR-INDUCTION MOTORS: Any one of the discussed capacitor-induction motors can be converted into a synchronous-capacitor-induction motor simply by changing rotors. The nonsynchronous rotor has a smooth periphery, while the synchronous rotor usually has flats or grooves on its periphery, giving it the desired number of salient poles. While the difference in the design of these two types of motors is practically all in the rotor construction, the windings of the stator must also be altered to some extent with respect to number of turns and size of wire. There are certain patented designs of synchronous motors on the market, covering the lower output ratings, that do not employ flats or grooves on the rotor periphery. Their discussion lies beyond the scope of this article.

Reversing of a four-lead synchronous-capacitor-induction motor is accomplished in the same fashion as its nonsynchronous kin, see *Fig. 3f*. Starting and reversing torque is lower than for the corresponding nonsynchronous motor, because the rotor poles exhibit a tendency to lock magnetically with the stator teeth. A high resistance rotor, larger air gap and larger capacitor improve the starting and reversing characteristics remarkably, but unfortunately impair the synchronous characteristics to the same extent. The result is that starting and reversing torques generally only approach the full-load torque. A larger number of poles would help but is limited by small

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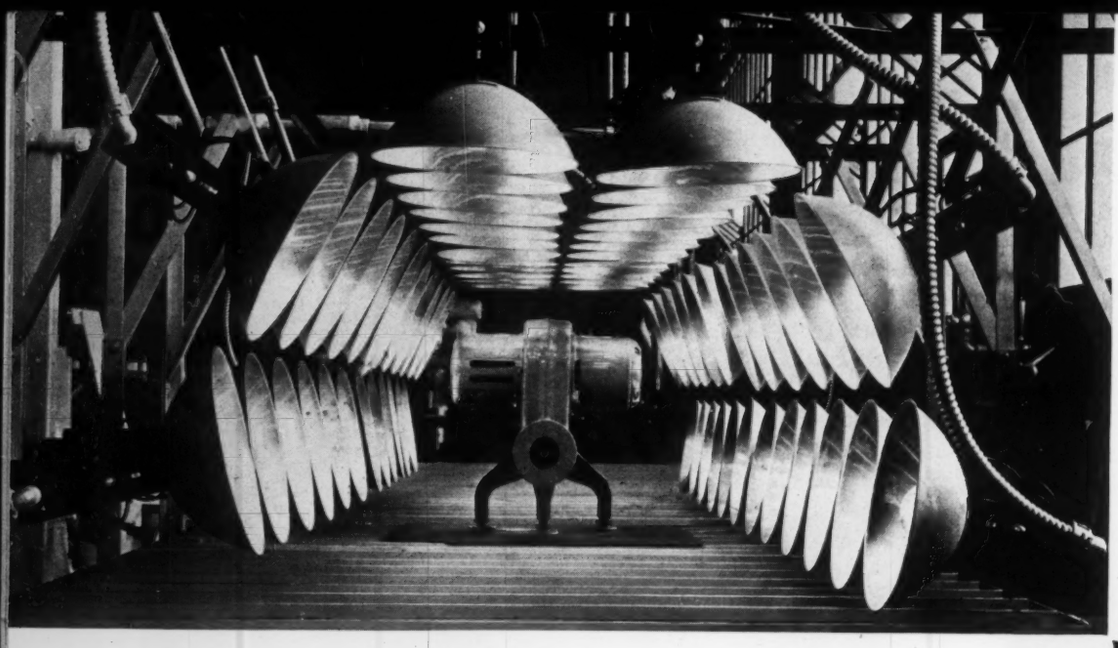
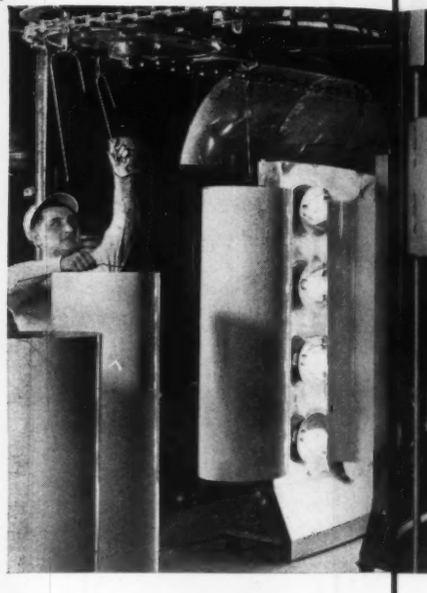


Fig. 1—Oil burner frame being baked under infrared lamps. Infrared rays are not inherently hot; they strike objects, are converted into heat



Infrared Baking Meets Modern Need for Speed

By M. M. Wilson
Ault & Wiborg Corp.

BAKING with infrared rays offers designers a method of curing industrial finishes which permits specifying a baked-on finish where an air-dry lacquer formerly was used. In many cases this harder, baked finish costs no more than the lacquer and it may actually save money by speeding production or reducing finishing costs. Although the method is comparatively new an impressive variety of parts, quite different in size, shape and physical characteristics is now being finished successfully with it.

Experience of one auto parts maker with infrared is illuminating, although admittedly exceptional. An annual saving on finishing materials of $40,000, or 57 per cent, has been realized, and retouching after assembly has been eliminated. Operating costs are lower and 5000 square feet of floor space has been saved. The finishing operation is completed in less than ten minutes, and the parts are protected with a more durable surface than by the former lacquer finish.

Infrared radiation does not owe its baking powers to any mysterious inner forces nor to any characteristics peculiar to spectral rays. Infrared rays bake merely because it is a fact that when these rays strike many types of objects they are converted into heat. This heat bakes finishes in the same way that hot air in baking ovens bakes finishes.

Operations are conducted with banks of infrared lamps which may or may not be enclosed in a reflector-type oven. Methods of arranging the lamps depend on the size and shape of the part to be finished. For maximum efficiency the infrared banks should be enclosed in a metal oven, although successful operations are being carried on with lamps used in the open. Enamel finishes are employed, most of which are formulated especially for use with infrared, and include smooth finishes, wrinkles, hammered effects, and grains.

Polished Materials Reflect Rays

Some materials transmit infrared rays without converting them into heat. The rays pass through air without heating it to any appreciable extent. But these rays are stopped by a very thin layer of water, while other materials such as gold or highly polished brass or silver will reflect almost all of the rays and will not absorb or transmit them. Because of this it is impractical is some cases to use infrared heat for baking a clear finish on shiny brass objects or on similar highly polished surfaces which tend to reflect, rather than absorb, the infrared rays.

The engineer responsible for the design of a machine or part to be finished by the infrared method

should consider the effect of various colors on infrared baking times. In general, dark colors absorb the rays more easily than do light colors; the latter tend to reflect the rays. It is also up to the designer and the paint manufacturer to utilize finishing material so that all colors will bake under identical conditions of radiation. As a result of considerable research, a great variety of colors can now be baked in the same time-temperature cycle.

In the case of materials designed for hot air oven baking, it was found in the past that carbon black, one of the best black pigments, was an oxidation inhibitor and would not bake as well as other pigments. But with infrared radiation the black creates

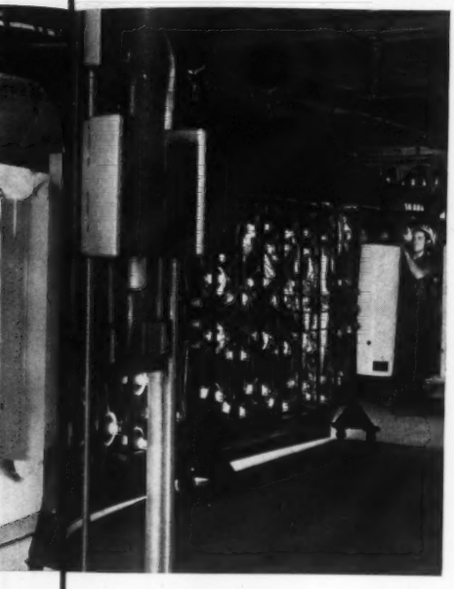


Fig. 2 — Left — Water heater jackets going through a battery of infrared lamps. Because of shape of jackets, lamps are needed only at sides. Fig. 3— Below—Infrared battery for cash register parts. Conveyor may be seen at top. Rays strike parts from every side

an acceleration of drying, rather than a retardation. Black tends to absorb more of such radiation than do any other colors and thus bakes more quickly. Hence finishes designed for use in infrared radiation ovens must be considered in the opposite manner from what they are for use in hot air convection ovens.

Polished sheet steel will reflect more infrared rays than unpolished, while aluminum will reflect more than polished steel. Thus it will take an even longer time to bake finishes on aluminum than on polished steel, and a finish on unpolished steel bakes even more quickly.

Generally speaking, about anything that can be baked in a hot air oven can be baked with infrared. The limitations of infrared are usually only limitations to a certain degree. But they are important enough to warrant the consideration of the designer who is interested in creating parts or machines most easily adapted to obtaining the maximum advantages which may be achieved with infrared. The results will justify the trouble.

Most of the baking by infrared radiation so far has been on metal, although good results have recently been obtained with finished plastic products. Metal of course conducts heat easily and for this reason finishes on thin sheets bake out more quickly than do finishes on heavy metal parts. For this reason, in the baking of miscellaneous articles which have both light and heavy portions, it is difficult to get a proper bake on the heavy part without overbaking the finish on the thin part.

The design problem of finishing a machine or assembly incorporating several gages of metal may be summed up with this statement: If it is desirable to use the same formulation for finishing the entire object, the metal units incorporated should be as close to the same gage as possible.

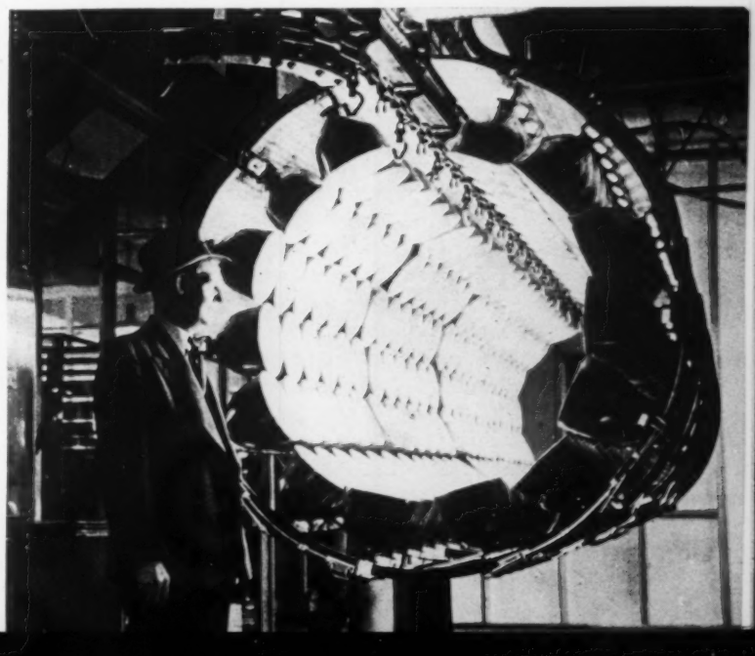
It is difficult to bake hidden parts of objects. The infrared rays have to strike directly at least one side of the metal surface which is finished and which is to be baked, but will also bake the finish on the opposite side of the metal.

Conduction Heats Other Sides of Metal

In the case of metal objects, conduction will take care of hidden parts to a certain extent, but in the case of nonmetallic objects, conduction cannot be counted upon to do this work. Hence anything the designer can do to eliminate or to minimize hidden parts or inside surfaces requiring a baked finish and which will not be reached directly by the infrared rays, will help to make the finishing operation more efficient and the ultimate product more completely protected.

The flexibility of infrared lamp banks makes possible the use of baked finish on objects of any reasonable size. The designer can assume that any object which a conveyor system can conveniently carry can be run through an infrared oven. And on the other hand, finishes are being baked by portable infrared units on objects which do not lend themselves to conveyor line operations.

Many factors are involved in the successful use of an infrared system, and the designer has control over most of them. As with any other process, if full advantage of infrared baking is to be realized the part or machine must be designed to meet the requirements of this finishing method.



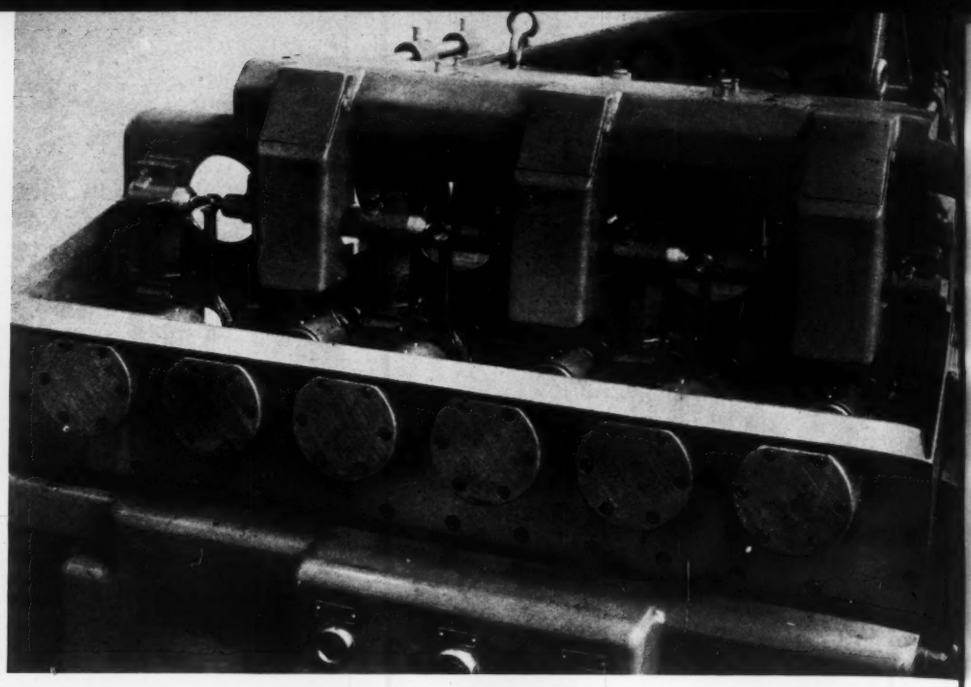


Fig. 14—Socket head screws afford advantages of accessibility and flush surface in this connecting rod boring machine

Machine Fastenings in Design

Part III—Special Screw Heads and Fastening Systems

By Kenneth D. Moslander

ADVANTAGES accruing from the use of hexagon socket head screws and bolts afford the design engineer many opportunities to improve appearance, reduce machine weight and eliminate safety hazards resulting from projecting bolt or screw heads on moving machine parts.

Illustrated in *Fig.* 14 is a Heald Bore-Matic for finishing engine connecting rods. The manifold applications of socket head screws in this assembly demonstrate, in addition to the aforementioned advantages, the manner in which screw heads of this type lend themselves to being designed into locations which, were ordinary hexagon heads to be used, would be inaccessible by wrenches.

Whereas socket head screws are normally made of heat-treated chrome nickel alloy steel they are available also in a number of different metals and alloys. In addition to American National thread forms, such threads as Dardelet and Whitworth are obtainable.

Among the types of screws which are available with these heads are machine screws and bolts, stripper bolts, pipe plugs and set screws. The latter are obtainable in standard point styles including cup, cone, oval, flat, half and full dog.

Logically included in this discussion of special heads is a self-locking cap screw which owes its locking effect to elastic deformation of the screw head, imposing a preloading tension on the shank. This screw has a hex head, the top of which is cold forged with a roughly hemispherical recess concentric with the axis of the screw. On the lower face of the head adjacent the shank fillet, an annular groove is formed. The method of construction results in a reduced cylindrical section between the groove and the hemispherical recess which is capable of elastic deflection under the reaction of the head on the work. This attribute is enhanced by the alteration of the fiber direction resulting from cold forging. A residual amount of elastic

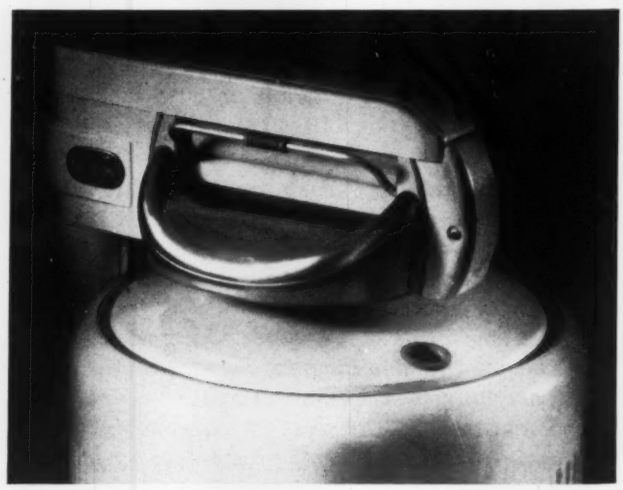


Fig. 15—Recessed head screw used in wringer assembly provides a snag-free, flush and neat appearing fastening

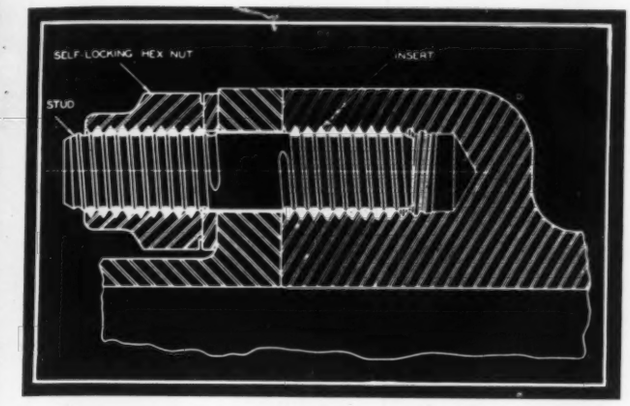


Fig. 16—Wire insert and special screw thread protect work and give maximum fatigue strength

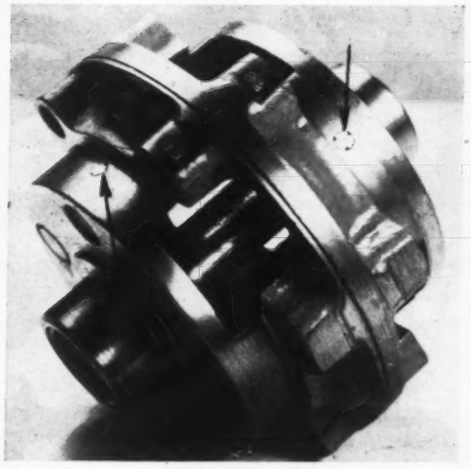


Fig. 17—Maximum vibration resistance is a feature of the grooved type pins used in above coupling assembly

Fig. 18—Stitching of fabric to sheet metal is one of the many applications of this wire stitching process

deflection normally remaining after tightening serves the further purpose of protecting the screw from fracture as a result of shock loads encountered in service.

Illustrated in the wringer assembly of a washing machine shown in *Fig.* 15 is a type of recessed head screw which is so well known that any detailed discussion of its advantages is unnecessary. To the machine designer, whose interest extends beyond the facility with which these screws are driven, the snag-free, burrless heads adapting the screws to re-use and adjustment without risk of damage, are finding wide application particularly on popularly operated machines. Obtainable from a number of licensed manufacturers, these recesses are available in practically all headed screw fastenings.

Another type of recessed head screw which provides substantially the same advantages has but one diametrical slot or recess. The thrust faces of this slot are practically radial so that the width increases as the distance from the center of the head. The outer ends of the recess are partially spiral in form, converging toward the center of the head in the direction of tightening rotation. Thus when a screwdriver is inserted in the slot and turned through a small angle in the direction of driving the screw, the spiral outer walls of the recess grip the driver and cling tightly to it. In this manner the screw can be fastened to the driver for insertion in otherwise inaccessible locations. A slight backward twist releases the screw driver.

Inserts Provide High Fatigue Strength

In machine assemblies where maximum fatigue strength is essential the special thread system illustrated in *Fig.* 16 is widely applicable. Also, particularly in the aviation industry, where cap screws or studs are used widely in aluminum or other nonferrous machine parts, irreparable damage to the part caused by conventional screw thread failure can be avoided by use of this system. In the event of fastening failure due to over stressing or impact, the wire insert may be extracted and replaced without damage to the part.

The system consists first of a tapped hole, different in size but similar in form to the American National coarse thread series. Threaded into this hole on a special tool is a spring wire usually of stainless steel or phosphor bronze. The wire is so formed that its V-shaped edge springs into the tapped threads, wedging securely therein. The opposite side of the wire is semicircular in cross section and forms the thread which engages the specially formed screw. Capable of being produced by any conventional external thread forming system, the screw is completely devoid of all stress raisers. Thus it is suitable to the application of ordinary hardening processes of heat treating or casing with a greatly reduced risk of surface cracking. The fatigue strength of these screw fastenings is approximately twice that of those utilizing the National coarse thread of the same nominal size.

Phosphor bronze inserts are recommended for use with steel screws or studs because of the good bearing relationship between these materials. Stainless steel inserts should be used with screws of aluminum or alu-

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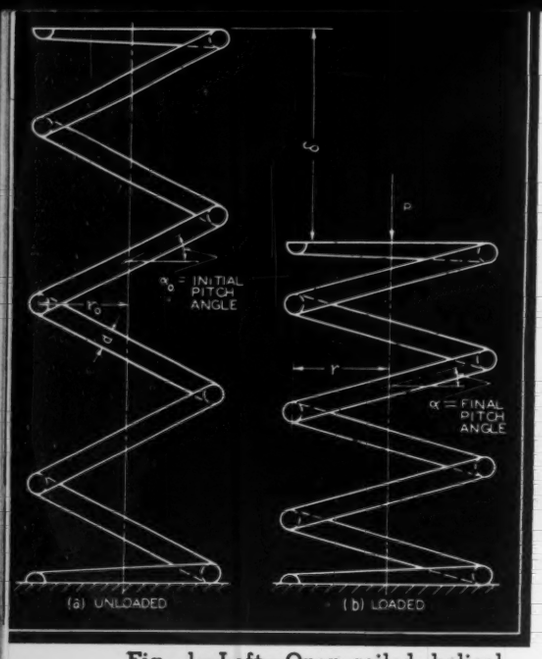


Fig. 1—Left—Open-coiled helical spring with large deflection

Designing Open-

Accurate formulas and ready-reference charts aid designers in applying helical springs with large pitch angles

By A. M. Wahl
Westinghouse Electric & Mfg. Co.

IN CALCULATING deflection and stress in helical springs, the usual formulas are based on the assumption that the pitch angle is small and that the coil diameter does not change appreciably during loading. For most spring applications these assumptions are sufficiently accurate. However, in certain cases where the deflection per turn exceeds the coil radius, spring deflections may be 10 per cent or more in error.

The primary reason for the inaccuracy in the usual formula where large deflections are present lies in the fact that the coil radius changes with the load. Since the spring constant, or spring rate, is inversely proportional to the cube of the coil radius, this factor becomes important. For open-coiled springs which have initially a fairly large pitch angle the effect is even more pronounced. For example, in *Fig.* 1*a* if r_0 is the initial coil radius of the unloaded spring, after loading, the coil radius increases to *r, Fig.* 1*b*. This means a decrease in rate. Conversely, the opposite effect occurs in a tension spring when loaded.

In the present article simple formulas and charts are given so that the spring designer may take such effects into account. The discussion will be limited to springs of fairly large index because the disturbing effects due to change in pitch angle usually occur with such springs[1].

When an open-coiled helical spring is loaded by an axial load there is a tendency for the coils to unwind, i.e., one end of the spring tends to rotate with respect to the other. If this rotation can take place freely and without restraint we have the condition of an axially

[1] Where the deflection per turn is not large (say not over half the coil radius) and the pitch angle is under 15 degrees, the curves given previously in MACHINE DESIGN, August, 1939, may be used for greatest accuracy for small and moderate indexes.

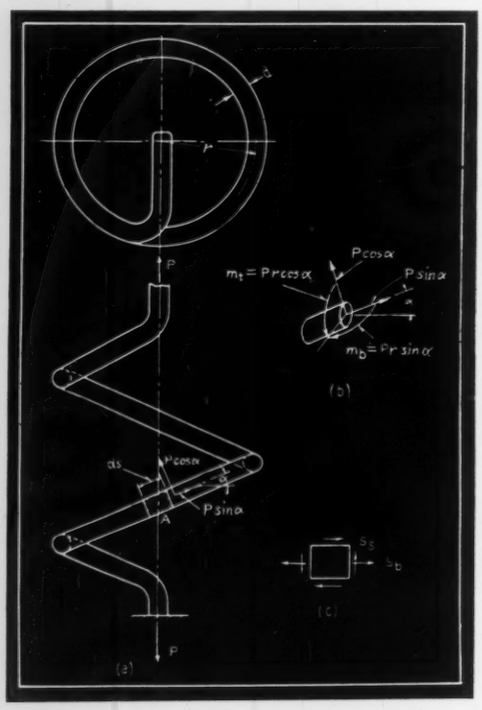


Fig. 2—Left—Axial load on open-coiled spring

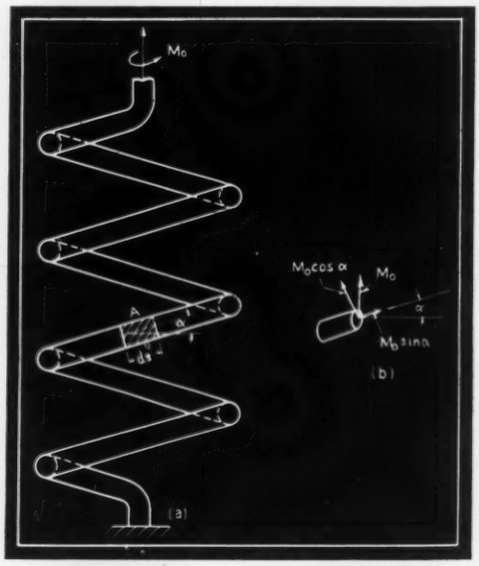


Fig. 3—End moments applied to open-coiled helical spring. Moments are represented by vectors

iled Helical Springs

loaded spring as indicated in *Fig.* 2*a*. This condition occurs in tension springs where the loops fit loosely. If the ends of the spring, however, are held rigidly or clamped (as is the case in most compression springs) this rotation cannot take place. Hence moments about the axis of the spring are set up as indicated in *Fig.* 3. For this reason it is necessary to distinguish two cases: 1. Open-coiled helical springs axially loaded and with ends free to rotate about the spring axis. 2. The same except that ends are fixed against rotation about the spring axis.

CALCULATION OF STRESS WITH ENDS FREE TO ROTATE: Consider an open-coiled spring of large pitch as shown in *Fig.* 2*a*, and subject to a tension load P, the ends being free to rotate about the coil axis. If α is the helix or pitch angle, and r the actual coil radius, the forces and moments acting on the element A of length ds from *Fig.* 2*b* will be a bending moment $m_b = Pr \sin\alpha$, a twisting moment $m_t = Pr \cos\alpha$, a shear force $P \cos\alpha$, and a tension force $P \sin\alpha$. Then the shear stress due to the twisting moment $Pr \cos\alpha$ will be (effects due to wire curvature being neglected)

$$S_s = \frac{16Pr \cos\alpha}{\pi d^3} \quad \ldots\ldots (1)$$

where d is the wire diameter.

The bending stress due to the bending moment $Pr \sin\alpha$ will likewise be

$$S_b = \frac{32Pr \sin\alpha}{\pi d^3} \quad \ldots\ldots (2)$$

Since the spring index is assumed large, stresses due to the direct shear $P \cos\alpha$ and the direct tension $P \sin\alpha$ will also be neglected for the present. Thus on an element of the surface of the coil we have the two stresses S_b and S_s acting as indicated in *Fig.* 2*c*.

It is common engineering practice to combine bending and shear stresses according to the maximum shear theory[2] of strength. By doing this we obtain an equivalent shearing stress, S_{se}, which is a measure of the strength of the spring. On the basis of this theory, the equivalent stress is:

$$S_{se} = \frac{1}{2}\sqrt{S_b^2 + 4S_s^2} \quad \ldots\ldots (3)$$

Using Equations (1) and (2) in (3) and simplifying:

$$S_{se} = \frac{16Pr}{\pi d^3}\sqrt{\sin^2\alpha + \cos^2\alpha} = \frac{16Pr}{\pi d^3} \quad \ldots\ldots (4)$$

since the term under the radical is unity.

This shows that if the maximum shear theory ap-

[2] See for example Timoshenko, *Strength of Materials*, Part II, p. 707, (Van Nostrand) for a discussion of this theory.

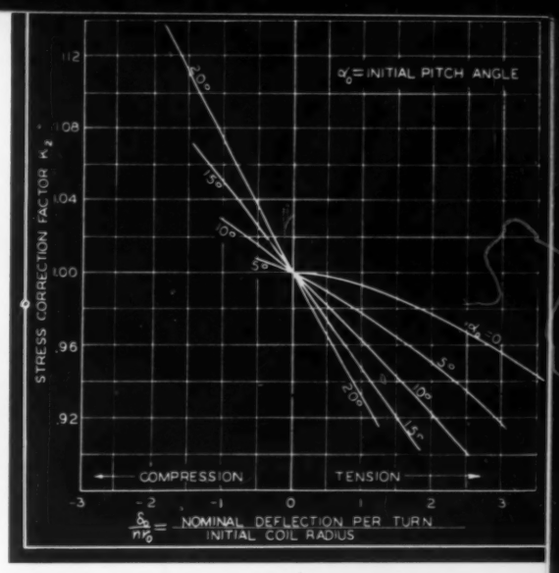


Fig. 4 — Stress correction factor when ends of spring are free to rotate

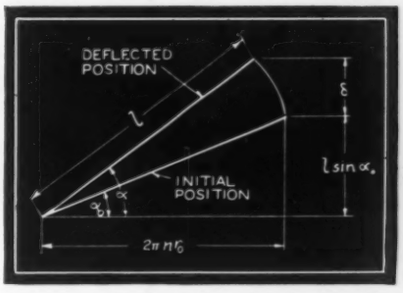
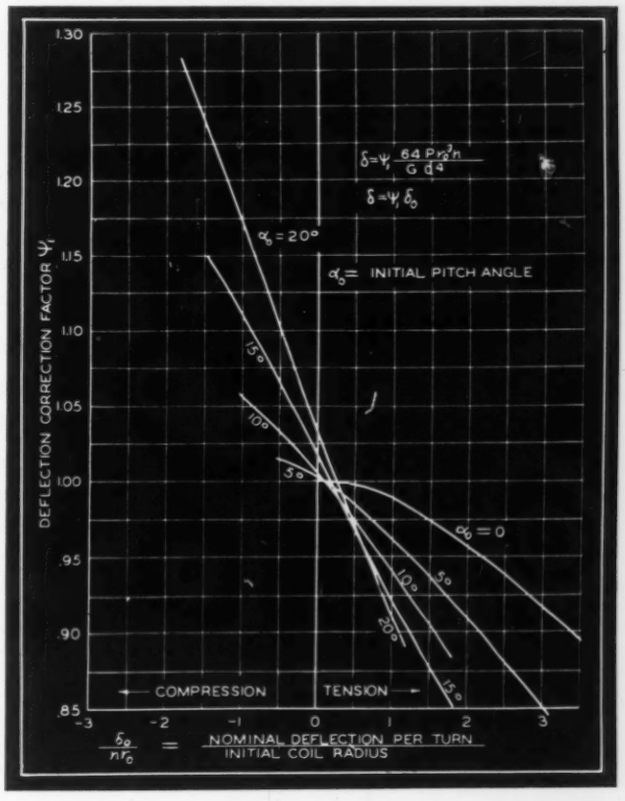


Fig. 5 — Right — Developed spring length for large pitch angle

Fig. 6—Below—Curves for deflection correction factor. Ends of spring are free to rotate



plies, the maximum equivalent stress is equal to that given by the ordinary formula regardless of pitch angle, effects due to curvature and direct shear being neglected, and provided that the coil radius r is taken as that actually existing when the spring is loaded. In general, r will be somewhat different from the initial coil radius r_0.

Another strength theory which has been coming into prominence in recent years is the shear energy (von Mises-Hencky) theory[2], on the basis of which the equivalent stress is given by:

$$S'_{se} = \sqrt{S_s^2 + \frac{S_b^2}{3}} \quad \ldots\ldots (5)$$

Using equations (1) and (2), we find

$$S'_{se} = \frac{16Pr}{\pi d^3}\sqrt{\cos^2\alpha + \frac{4\sin^2\alpha}{3}} \quad \ldots\ldots (6)$$

A comparison of Equations (4) and (6) shows that when applied to an axially loaded helical spring the difference is less than 2 per cent for pitch angles under 20 degrees, and below 4 per cent for pitch angles under 30 degrees. In view of this small difference the simpler formula of Equation 4, based on maximum shear theory, will be used in the following discussion and equations.

In calculating springs, it is simpler for the designer to use the coil radius r_0 at zero load (*Fig.* 1) as a basis for calculation since it is a quantity easily measured. It is shown below in Equation (13) that for an axially loaded spring $r = K_2 r_0$. By using Equations (13), (15) and (16) below, K_2 may be expressed as a function of the ratio of nominal deflection per turn to initial coil radius, and of the initial pitch angle α_0 (or pitch angle at zero load). The nominal deflection which is figured by the ordinary spring deflection formula is

$$\delta_0 = \frac{64Pr_0^3 n}{Gd^4} \quad \ldots\ldots (7)$$

where G is the modulus of rigidity and n the number of active turns. Then the equivalent stress becomes:

$$S_{se} = \frac{16Pr}{\pi d^3} = K_2\frac{16Pr_0}{\pi d^3} \quad \ldots\ldots (8)$$

This stress is thus expressed simply as the usual formula multiplied by the factor K_2. Values of δ_0/nr_0 may be calculated from Equation (7) for a given load P; knowing these values and the initial pitch angle α_0 the factor K_2 may be read from *Fig.* 4 and the stress computed from Equation (8). It should be noted that negative values of δ_0/nr_0 correspond to spring compressions, postive values to extensions. The factor K_2 is greater than unity for compressions since the coil radius increases as the spring is compressed; the opposite effect occurs for extensions. From these curves it may be seen that if α_0 is below 10 degrees and the nominal deflection per turn δ_0/n is not more than the initial coil radius r_0 errors in the stress formula due to pitch angle changes are under 4 per cent. This error may reach 15 per cent for pitch angles around 20 degrees and deflections per turn equal to the coil diameter.

During this discussion, to determine the effect of pitch angle changes, the effect of bar curvature and direct shear load on stress has been neglected. To take these effects into account, as an approximation the stresses as figured in this way should also be multiplied by a correction factor depending on the spring index as discussed in a previous article[3] since even for fairly large indexes, say 10 to 20, the stress will be increased from 7 to 14 per cent because of curvature and direct shear.

CALCULATION OF DEFLECTION WITH ENDS FREE TO ROTATE: Assuming that a helical spring is axially load-

[2] MACHINE DESIGN, February, 1938.

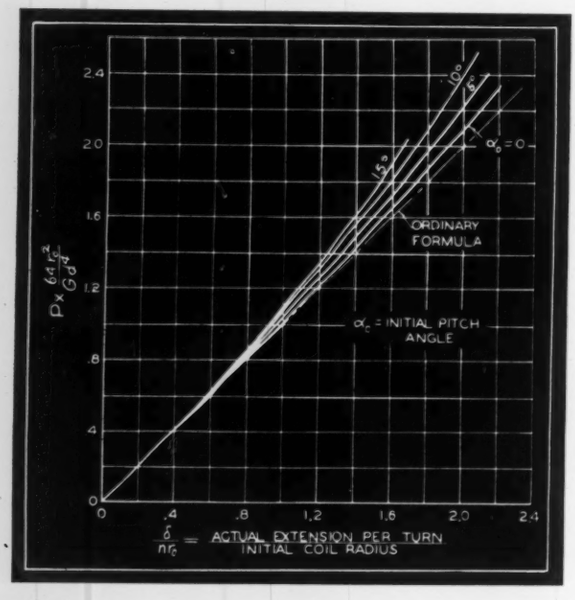


Fig. 7—Load extension diagrams for open-coiled spring with ends free to rotate

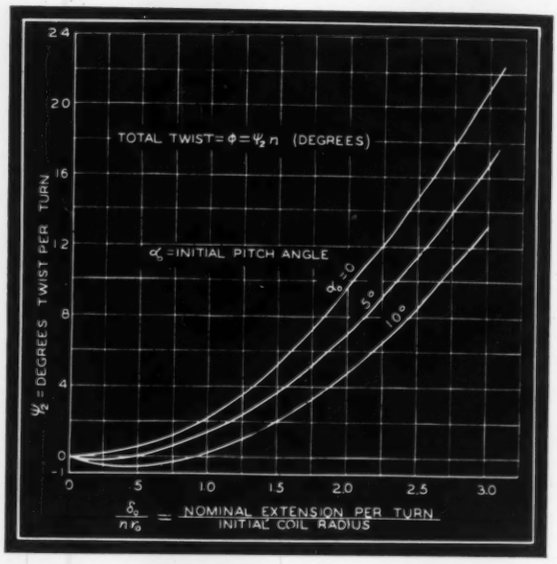


Fig. 8—Curves for calculating twist of spring ends for tension springs with ends free to rotate

ed with the ends free to rotate about the spring axis as the spring deflects, *Fig.* 2, it can be shown by the theory of elasticity[4] that the change in the bar or wire curvature is given by:

$$\triangle K = \frac{\cos^2\alpha}{r} - \frac{\cos^2\alpha_0}{r_0} \quad \ldots\ldots (9)$$

where α_0 and r_0 are the initial pitch angles and coil radius, respectively, and α, r the final values. The

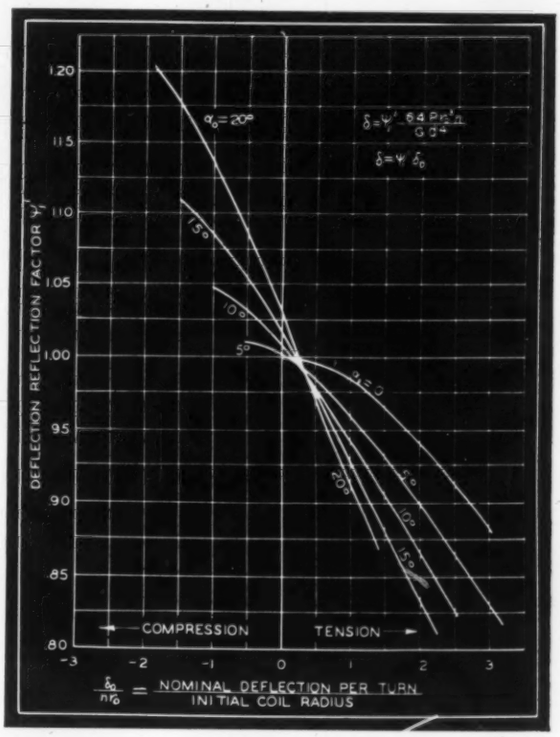


Fig. 9—Deflection correction factor for springs with ends fixed against rotation

bending moment for an axially loaded spring is $Pr\sin\alpha$ and this must be equal to the flexural rigidity EI multiplied by the change in curvature (E = modulus of elasticity of material, I = moment of inertia of cross section). Thus

$$P = \frac{EI\triangle K}{r\sin\alpha} = \frac{EI}{r\sin\alpha}\left(\frac{\cos^2\alpha}{r} - \frac{\cos^2\alpha_0}{r_0}\right) \quad \ldots\ldots (10)$$

From the condition that the axial moment is zero (since only an axial load acts) elastic theory[4] gives

$$GI_p\left(\frac{\sin\alpha\cos\alpha}{r} - \frac{\sin\alpha_0\cos\alpha_0}{r_0}\right) = -\frac{EI}{\tan\alpha}\left(\frac{\cos^2\alpha}{r} - \frac{\cos^2\alpha_0}{r_0}\right) \quad \ldots\ldots (11)$$

where G = modulus of elasticity in shear and I_p = polar moment of inertia of cross section.

Using these two equations the following is obtained

$$P = \frac{EIr_0}{r_0^2 r}\left(\frac{\cos^2\alpha_0 - \frac{r_0}{r}\cos^2\alpha}{\sin\alpha}\right) \quad \ldots\ldots (12)$$

[4] Love, *Theory of Elasticity*, 3rd Edition, p. 421.

where

$$\frac{r_0}{r} = \frac{\sin\alpha_0\cos\alpha_0\tan\alpha + \frac{EI}{GI_p}\cos^2\alpha_0}{\cos^2\alpha\left(\frac{EI}{GI_p} + \tan^2\alpha\right)} = \frac{1}{K_s} \quad \ldots\ldots (13)$$

Assuming that the active length l of the spring remains constant during deflection, which is reasonable for springs of large index, the spring length may be developed on the helix cylinder as indicated in *Fig.* 5. As the pitch angle increases from its initial value α_0 to its final value α, the total deflection becomes:

$$\delta = l(\sin\alpha - \sin\alpha_0) \quad \ldots\ldots (14)$$

Since $l\cos\alpha_0 = 2\pi nr_0$, where n is the total number of active coils, this equation becomes:

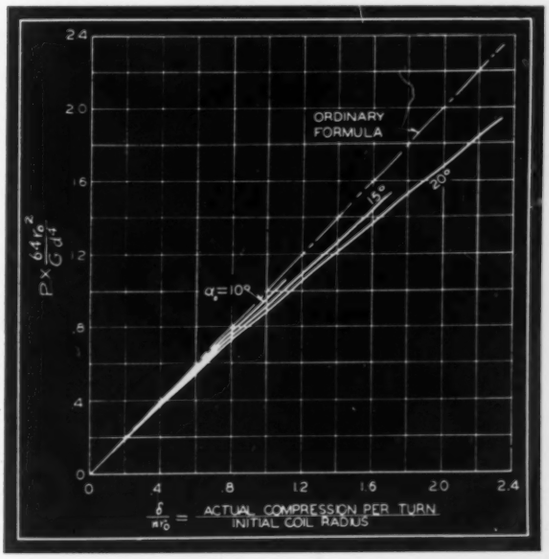
$$\delta = \frac{2\pi nr_0}{\cos\alpha_0}(\sin\alpha - \sin\alpha_0) \quad \ldots\ldots (15)$$

Using Equations (7), (12) and (15) the total deflection δ of the spring may be expressed as the nominal deflection δ_0 multiplied by a factor ψ_1, as follows:

$$\delta = \psi_1\delta_0 = \psi_1\frac{64Pr_0^3n}{Gd^4} \quad \ldots\ldots (16)$$

In this, ψ_1 depends on the initial pitch angle α_0, the ratio E/G between bending and shear moduli, and the ratio δ_0/nr_0. Values of ψ_1 have been calculated for a ratio $E/G = 2.6$ corresponding to Poisson's ratio equal to .3 which applies for most spring steels. The results are plotted in *Fig.* 6, from which it may be seen that for initial pitch angles α_0 below 10 degrees and deflections per turn less than half the coil radius ($\delta_0/nr_0 < .5$) the error in the usual formula is not over 3½ per cent, i.e., ψ_1 does not differ from unity by more than about 3½ per cent. However for pitch angles around 20 degrees and deflections per turn equal to the initial coil

Fig. 10—Load compression diagrams for open-coiled helical compression springs. Ends are fixed against rotation



radius, the error may be as much as 15 per cent, i.e., $\psi_1 = 1.17$.

To use *Fig.* 6 for a practical calculation of open-coiled springs it is merely necessary to determine the deflection δ_0 for the given load P using the ordinary spring formula, Equation 7, or by means of spring tables or charts. From δ_0, n and r_0 the ratio δ_0/nr_0 may be calculated. Since the initial pitch angle α_0 is known from measurements of spring dimensions, the factor ψ_1 may be read from *Fig.* 6, interpolation being used for intermediate values of α_0. The deflection at the load P is then $\psi_1\delta_0$.

Although a ratio $E/G = 2.6$ between tension and torsion moduli of elasticity has been assumed in the calculations given in this article it is believed that considerable deviation from this value would make only a small difference in the final results.

To show how the load deflection diagrams in tension springs deviate from a straight line due to change in pitch angle and coil radius the curves of *Fig.* 7 have been plotted for various initial pitch angles for the free end condition. It may be seen that the curves are concave upward which means an increase in spring rate with load. Also at large deflections, there is a considerable deviation from the ordinary formula, even for small initial pitch angles.

Coils Tend To Unwind

ANGULAR TWIST OF SPRING UNDER LOAD: When a tension spring is stretched by a considerable amount the coils tend to unwind, as is well known. The amount of this angular motion or unwinding may easily be determined as follows: From *Fig.* 5, the angle in radians subtended by the projection of the total spring length in the unloaded position on a plane perpendicular to the axis will be

$$\phi_1 = \frac{l \cos \alpha_0}{r_0} \quad \ldots\ldots (17)$$

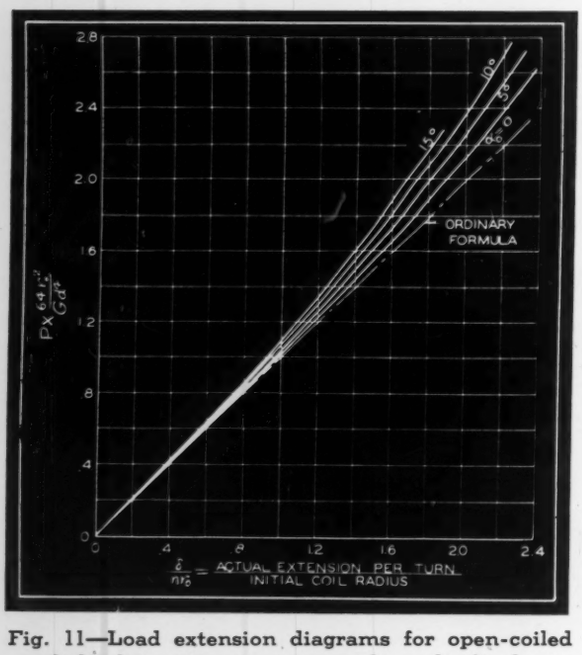


Fig. 11—Load extension diagrams for open-coiled helical tension springs with ends fixed

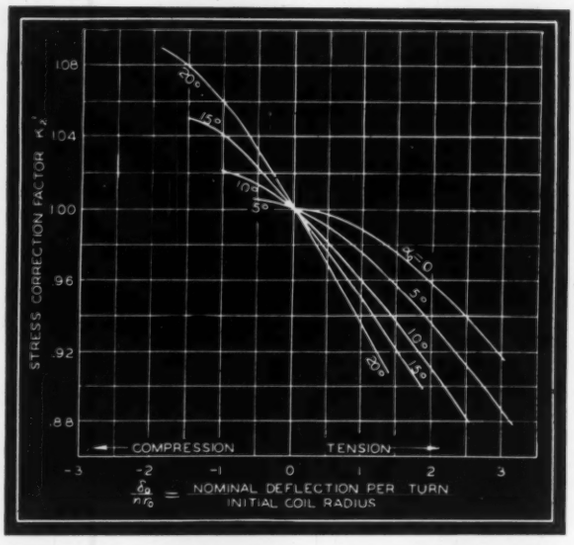


Fig. 12—Stress correction factor for springs with ends fixed against rotation

In this loaded position this angle will change to

$$\phi_2 = \frac{l \cos \alpha}{r} \quad \ldots\ldots (18)$$

The relative angular motion of one end of the spring with respect to the other, i.e., the amount the spring unwinds, will be the difference of these values or

$$\phi = \phi_2 - \phi_1 = l\left(\frac{\cos \alpha}{r} - \frac{\cos \alpha_0}{r_0}\right) \quad \ldots\ldots (19)$$

Since

$$l = \frac{2\pi n r_0}{\cos \alpha_0}$$

$$\phi = \frac{2\pi n r_0}{\cos \alpha_0}\left(\frac{\cos \alpha}{r} - \frac{\cos \alpha_0}{r_0}\right) \quad \ldots\ldots (20)$$

expressed in radians.

Using Equations (15) and (16) this angle may be expressed in terms of α_0 and δ_0/nr_0 as before. Expressing ϕ in degrees:

$$\phi = \psi_2 n$$

where ψ_2 is the twist per turn in degrees, read from *Fig.* 8. It will be noted that ψ_2 becomes slightly negative for small values of δ_0/nr_0 and for initial pitch angles greater than zero. This means that for small deflections the spring has a slight tendency to wind up, which is due to the fact that the distortions of the elements of the coil under axial load are in such a direction as to cause this action. As the load increases, this tendency is overbalanced by the change in pitch angle which causes an unwinding of the coil.

Fixed Ends Restrict Unwinding

CALCULATION OF DEFLECTION WITH ENDS FIXED: Where the spring ends are fixed, i.e., prevented from rotating about the axis of the spring, a similar analysis may be made. This condition holds approximately in

(*Continued on Page* 126)

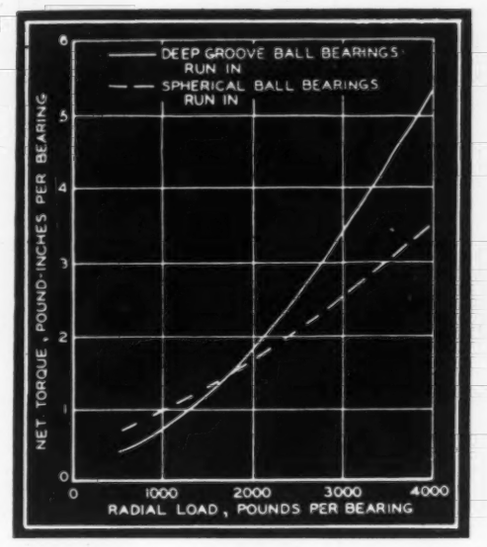

DEEP GROOVE BALL BEARINGS RUN IN
SPHERICAL BALL BEARINGS RUN IN
NET TORQUE, POUND-INCHES PER BEARING
RADIAL LOAD, POUNDS PER BEARING

Fig. 1—Curves show the effect of loading on the friction torque of run-in spherical and deep groove ball bearings

Factors Influencing Antifriction Bearings

By Haakon Styri

SKF Industries Inc.

MANY factors affect friction in ball and roller bearings but little has been published about the subject, probably because the power loss from friction in such bearings is relatively unimportant. The coefficient of friction varies considerably for different operating conditions and cannot be used satisfactorily for estimating power loss in bearings. It is simpler to use the direct determined friction torque which is a relatively simple function of load and speed of the bearing but differs for different types of bearings. The amount and viscosity of the oil used for lubrication has a great effect on the torque, and the lowest torque is obtained with a very thin oil film.

In a previous paper by the author, which summarized friction tests under

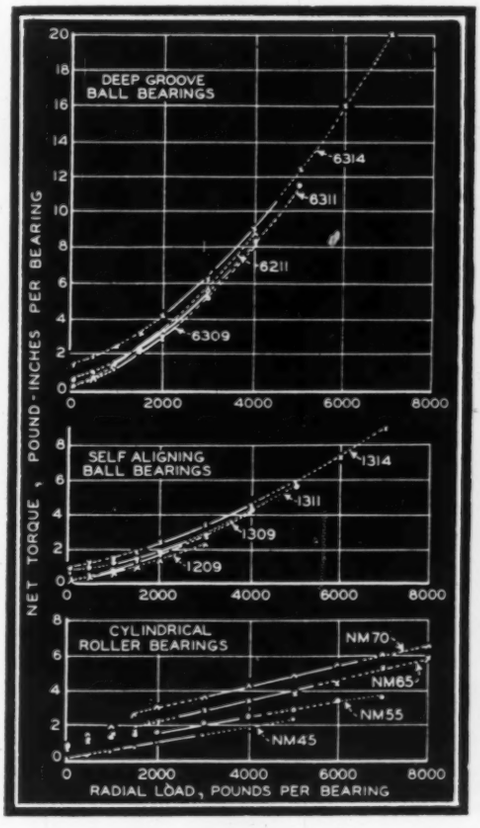


Fig. 2—Adjacent—Friction torques are plotted against load in these curves for deep groove and self-aligning ball bearings and cylindrical roller bearings

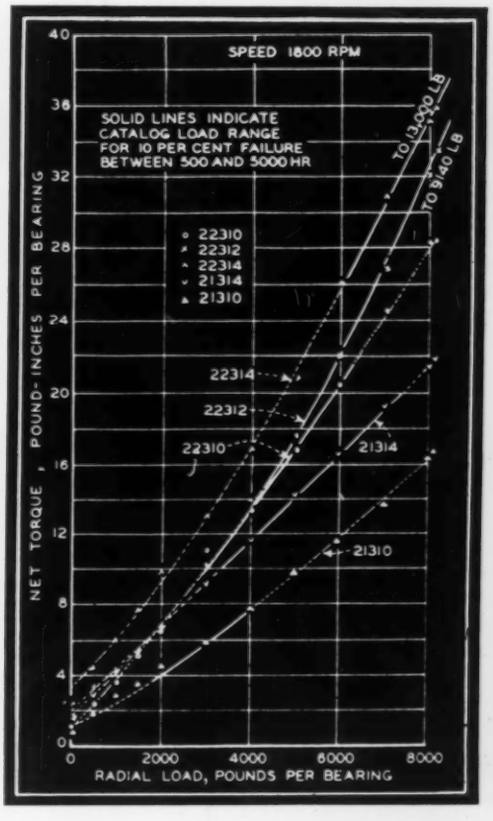


Fig. 3—Extreme right—Similar to Fig. 2, these curves show the friction torque for spherical roller bearings

loads from 500 to 4600 pounds at speeds of 600 to 2000 revolutions per minute, it was shown that the coefficient was influenced little by change in speed. With change in load, however, it was found that the values were high for low loads and approached minimum for loads given in most catalogs at speeds in the range 1000 to 2000 revolutions per minute. The use of the coefficient of friction as a basis for estimating power loss in antifriction bearings was therefore considered arbitrary and misleading. It would be simpler to use the measured friction torque directly for this purpose, because it varied almost linearly with the load and was practically independent of speed for small amounts of lubricant. It was even more interesting that the friction torque for the same external load did not differ much when bearings of not too greatly different sizes and of the same type were compared and provided the applied load was not much higher or much lower than what would be considered a service load. Bearings of different types would, however, have different torques for the same load.

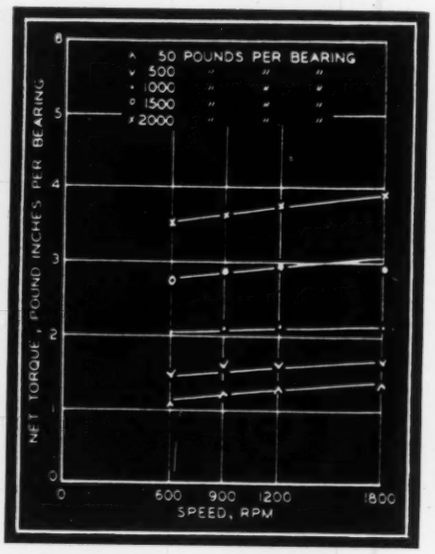


Fig. 4—Variation of friction torque with speed is less than with load for groove bearings

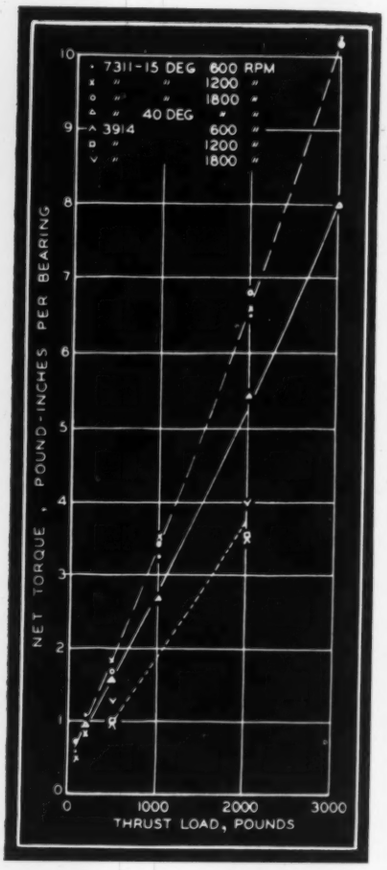


Fig. 5—Right—Loss in thrust bearings versus load is shown for the angular contact type (7311) and the pure thrust type (3914)

Another objection to the use of the coefficient of friction is that various sizes and types of bearings can be used for the same shaft diameter, and there are bearings of exactly the same internal construction and, therefore, with the same frictional characteristics, that have bores of different sizes.

The power loss and the resulting heat are really what interest us, and since the power loss is directly proportional to the friction torque that is determined by direct measurements, it would seem natural to select the torque as the basis for comparing friction in bearings. A plot of torque curves for bearings which have been "run in" is shown in *Fig.* 1.

IN the article which appeared in the January issue, "Factors Influencing Power Loss in Bearings," *the effect of surface finish and lubrication on plain bearings was analyzed. This article, abstracted from a paper presented at the recent A.S.M.E. annual meeting, discusses how friction torque of ball and roller bearings is influenced by lubrication and operation*

In order to present the problem in a relatively simple form, only standard bearings were selected for the investigation, that is to say, bearings with standard groove radii and internal fits and with external dimensions within standard tolerances. The friction losses in a simple rubber-hose coupling used in the tests were found by prony-brake measurements to be negligible.

Earlier studies of lubrication had indicated that the quantity of lubricant greatly influenced the friction, and in order to minimize this factor the first runs were made with as small an amount of oil added for lubrication as was considered safe for continuous operation. The quantity selected was one drop of oil per bearing per hour except for the spherical roller bearings which were given several drops per bearing about one-half hour before each test.

In *Fig.* 2 the torques are plotted against load for groove-type bearings (6200-6300 series), self-aligning ball bearings (1200-1300 series), and cylindrical roller bearings (NM series). In *Fig.* 3 the torques for the spherical roller bearings (series 21,300 and 22,300) are shown. The solid lines in the graphs indicate the load range given in the makers' catalogs for 10 per cent failure between 500 and 5000 hours at 1800 revolutions per minute. The torques at the same load for bearings within this range do not vary much in the groove-type or in the self-aligning ball series, but differ in the roller-bearing series. Bearings in which the rolling elements are guided by pressure against flanges (21,300-22,300 series) have higher frictional torques than ball bearings for the same loads. In *Fig.* 4 the torques are plotted against speed for groove bearing 6314 at various loads. The pillow-block mounting used for this test differed from the open housings used for data in *Figs.* 2 and 3, but it is clearly seen that with film lubrication torque is little affected by speed change.

The bearings discussed so far all represent types where the rolling elements have relatively pure rolling, except for the sliding against guide flanges under fairly light load. It was of interest to see if similar relations of torque to load and speed would hold for ball thrust bearings where there is considerable spinning of the balls. Results from tests on three different thrust bearings, namely, two of the angular contact type (size 7311) with angles of contact for the balls of 15 and 40 degrees respectively, and one of the pure thrust type (size 3914) are shown in *Fig.* 5. In this case the amount of lubricant was one drop per minute applied at the top of the stationary race.

It is evident that the torque for the angular contact bearings under thrust is higher than for the pure thrust bearings and greater for the 15-degree than for the 40-degree contact angle, because of greater load per ball. The torque per bearing, however, does not increase proportionately to the load per ball. Again, variation in speed does not greatly influence the torque except that for the pure thrust bearing the torque at the highest speed (1800 revolutions per minute) is consistently higher than it is at the two lower speeds, which indicates the wedging influence of the ball as a result of centrifugal force, or gyroscopic forces. The torques of thrust bearing 3914 for loads less than 500 pounds could not be determined reliably on the horizontal dynamometer, as less thrust was insufficient to prevent eccentric displacement of the row of balls.

Quantity of Oil Effects Losses

A more detailed study of the influence of quantity and viscosity of lubricant on friction was also of interest and for this purpose tests were run on various sizes and types of bearings. *Fig.* 6 shows the change in net torque with decrease in quantity of oil down to one drop every four hours of the medium oil. The greatest change in torque is from several drops per minute to one drop per hour, after which the change for decreasing oil is smaller. For the 7311 angular contact bearing, oils of three viscosities were used, S. A. E. 50, 750 Saybolt universal seconds at 100 degrees Fahr.; medium oil, 284 Saybolt universal seconds at 100 degrees Fahr.; and spindle oil, 97 Saybolt universal seconds at 100 degrees Fahr. It was surprising to find in this case that the torque for the heaviest oil, S. A. E. 50, was lower than that for the medium oil while the lowest torque as expected was obtained with spindle oil which has the lowest viscosity.

Torque Increases Linearly with Load

A number of tests have been run with small quantities of oil and for extended time after completely shutting off the oil supply. When the oil supply has been stopped, it is found that the torque eventually reaches a minimum and thereafter increases, first slowly and then rapidly, until possible smearing or destruction of the bearing occurs. The oil film on the ball track at the minimum point certainly must be very thin since bearings often can run up to hundreds of hours before the torque increases.

Smaller deep groove bearings (size 6205 and 6305) and self-aligning (sizes 1205 and 1305) were tested in a small dynamometer. The torque increased approximately linearly with the load, and for small quantities of oil (film lubrication) it was found as expected that the torque does not change much with speed for the groove bearing, but somewhat more for the self-aligning bearing. However, when the amount of oil is increased torque increases more rapidly with speed.

These tests show clearly that an increase in speed has little effect on the torque when the lubrication is light, but that the increase in torque is considerable with increase in speed when the oil level is up to the center of the lowest ball. The torque also increases with increase in viscosity of the oil, but increase in torque with increase in load is practically independent of the quantity of oil. The power loss resulting from churning of the oil may be higher than the power loss resulting from friction of the bearing alone, depending on size and type of bearing, construction of housing, oil used, and operating conditions.

It has been the purpose of the foregoing to discuss the principal factors that affect the friction, namely, load, speed, quantity and viscosity of oil, and type of bearing, and to avoid discussion of other important factors such as fit of bearings, internal construction, surface finish of grooves, and lubrication with greases.

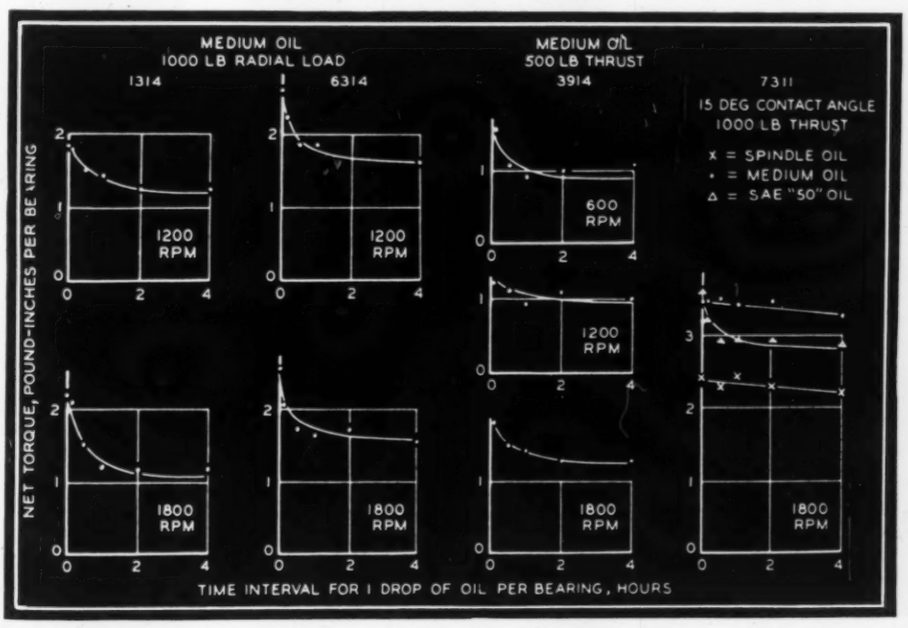
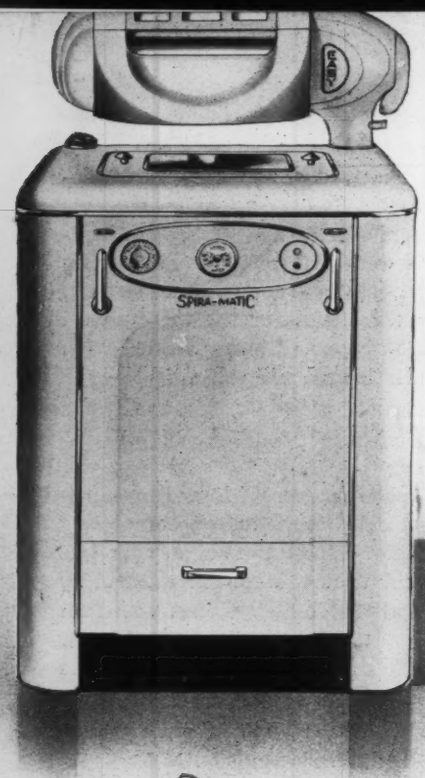


Fig. 6—Effect of the quantity of lubricant on the friction torque is shown by curves



Lamp inside tub of Easy washer (left) sterilizes clothes, while an electrical heating element under the tub keeps water temperature at efficient washing heat. Heat resistant glass-windowed top permits view of action. Roll release bar may be touched lightly from any four-way position and rolls spring wide apart and stop automatically. Wringer is die cast and cabinet trimmed in rust and chip-proof enamel with chromium trim

Cutter of Mall door type plane (left, center) is driven at 18,000 revolutions through a clutch mounted on the armature shaft. A solid piece of heat treated alloy tool steel comprises the two-blade spiral cutter. Motor housing and the main shoe are cast aluminum, while the beveling fence is aluminum alloy heat treated to withstand shocks. On-off switch is located for convenient operation

Design
IN NEW

(For new mac

THIS MONTH'S COVER. A
prene sealing disks are used to se
jonnier vacuum filler-crowner. Si
and crowner to accommodate co
of a cross-shaft carrying two pini
columns of both the filler and cr
crowner are lubricated by force
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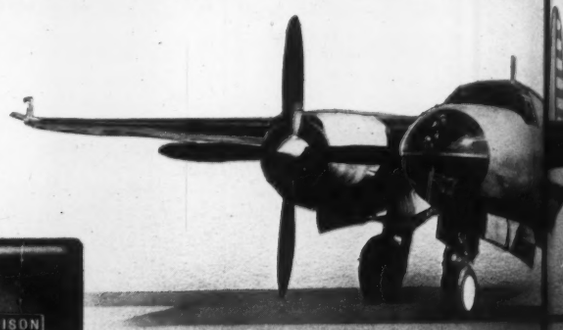

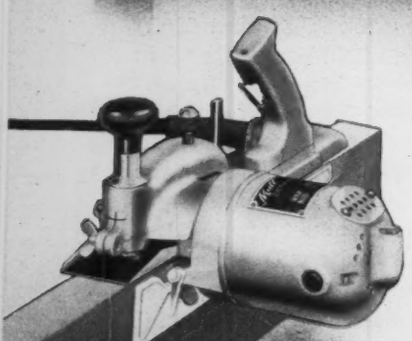

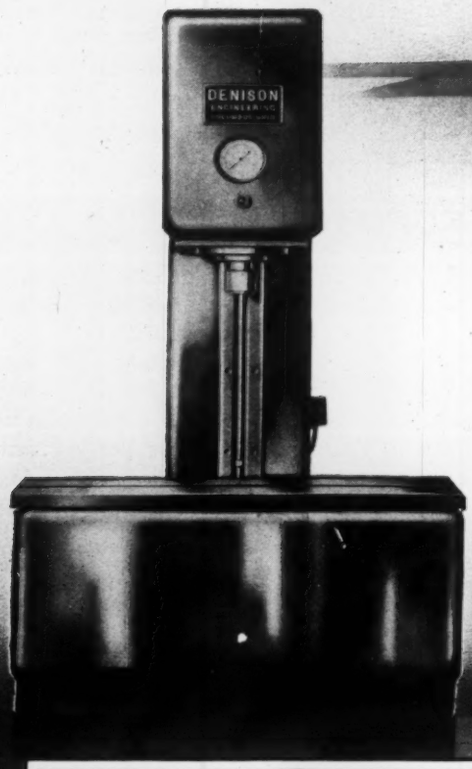

Constant volume hydraulic vane type pump is mounted with motor in the center section of the Denison straightening press (above, left). Accurately finished steel cylinder with nickel alloy iron cylinder head are in upper part of frame, along with ram. Direct control of four-way directional control valve, balanced piston type, is obtained through a shipper rod supported in four bearings and mounted between the vertical guides in the throat of the press

Work table of Vandercook printing block leveller (left) was formerly hand started and friction driven, but now has an individual motor controlling the speed of rotation. Foot pedal starts both cutter and table motors and releases automatic brake on
cutterhead to blo
steel base.

Grinding wheel
is driven by V-be
constant speed mo
centrifugal pump
speed of the work
by wiring the wo
rheostat so that
to the diameter
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W ACHINES

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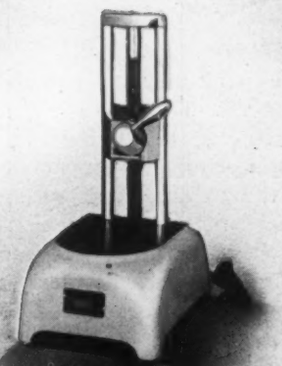
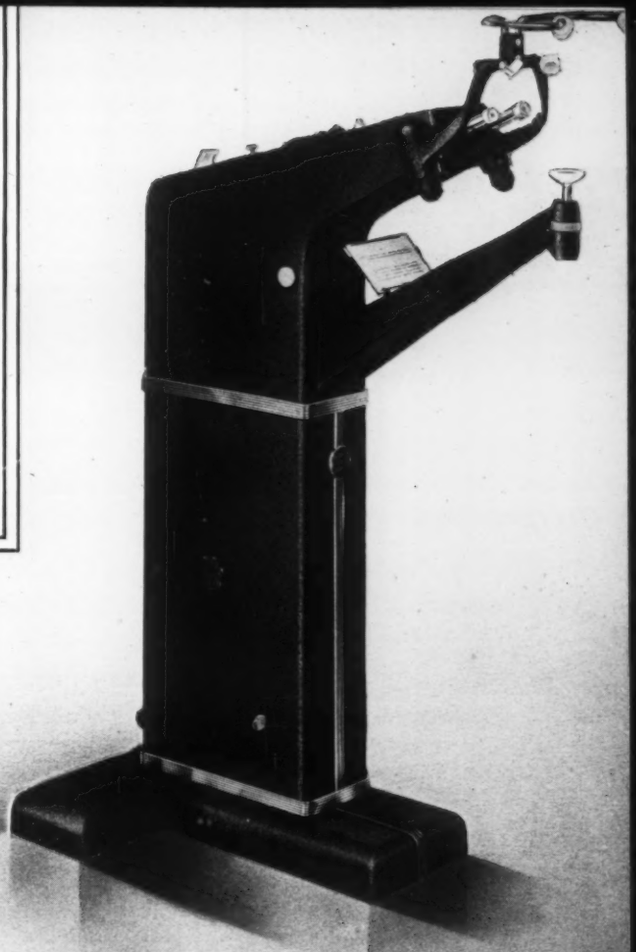
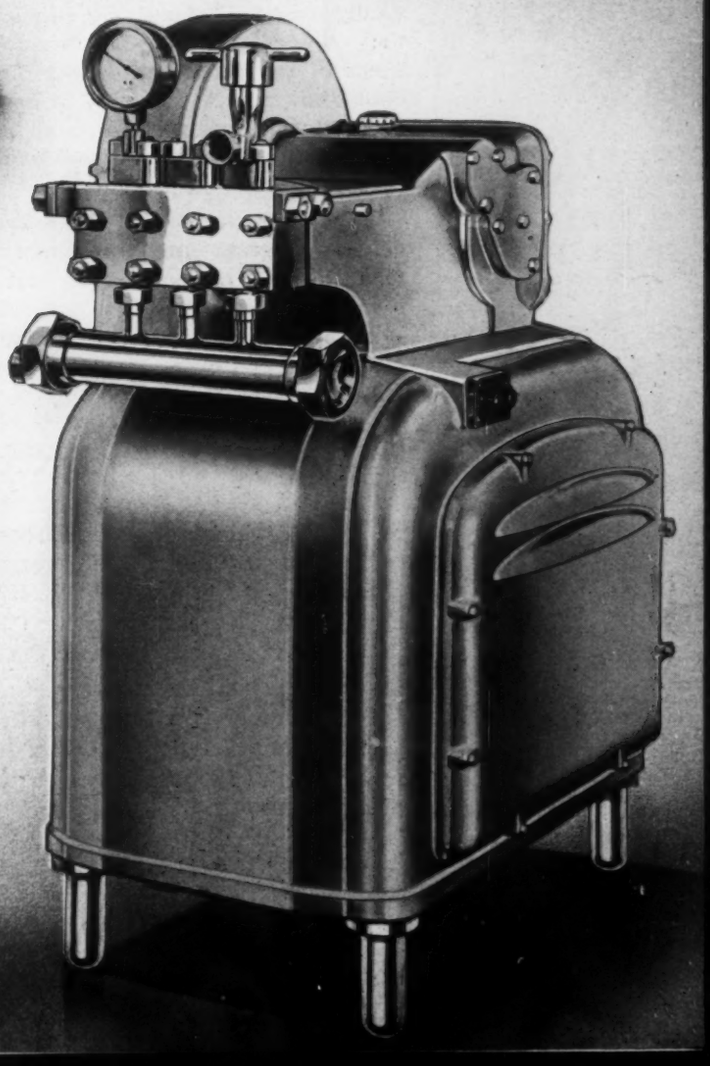
OVER. A lifting cylinders fitted with neo- used to s ers against filling heads in the Mo- owner. S raising and lowering of both filler nodate co various heights is effected by use two pinio g on gear racks cut in the center er and cro rings and gears on both filler and by force s which are not stainless steel are dblasted a etallized with zinc

American Optical ophthalmograph (right) photographs eye movements and automatically produces a fully developed and identified film. Specially designed quiet motor with silent chain drives the machine, and oilless bearings are used throughout. All exposed metal parts are finished in dull chromium set off by black wrinkle enamel. Counter-balanced springs within body of instrument provide ease in raising and lowering

Martin B-26 medium bomber (below) has power-driven, retractable turrets, self-sealing fuel tanks and protective armor, and is said to have greater speed than most pursuit ships. Wings are small and narrow. Engines are eighteen-cylinder radials, rated at 1850 horsepower. Tricycle landing gear brings nose close to ground, leading to use of four-bladed, automatic full feathering propellers







rake on ta r is contained in ad to blo o bag in welded el base. P ly accessible

g wheel o refacer (above) n by V-be half-horsepower speed mo o drives a packless gal pump coolant. Variable the work feature, is provided g the wor r in series with a so that sp varied according iameter a of the valve being Castings are rounded and ed, contr and centralized

andle con operation of Moto ster (righ Universal motor

drives knurled upright, which in turn causes can placed against it to revolve. Cutting blade is stationary, although it may be moved up or down. Exposed metal parts are chromium plated, cast base is finished in white enamel

Resilient stainless steel valves in Creamery Package homogenizer (right) break up fat globules more gradually and uniformly. Drive is from motor to countershaft by V-belt and thence to eccentric shaft by hardened spiral gears. Eccentric shaft is forged alloy steel, hardened and ground, and its bearings are babbitt with steel back. Piston type crossheads are used to give large wearing surface and freedom from alignment strain

MACHINE

Editorial

DESIGN

Work of Designers, Formerly Disparaged, Now Is Being Extolled

THE pendulum swings! That same design profession which a few years ago was being bitterly censured because of the progressiveness of designers in developing new labor-saving machines, now has the opportunity of building for itself a position of enviable importance in the welfare of the country. "Business as usual"—speaking of industry as a whole—is out, but not for engineers responsible for design. It is up to them to retain and materially extend the precept of this slogan in the development of production equipment that not only will turn out the vast quantity of parts needed but will also reduce the number of skilled operators required.

Outstanding in this connection is the machine tool industry. Almost "down and out" in the depression years of 1932-33 it has overcome all its problems of rapid expansion and now is producing 25 to 30 times the volume of machines turned out during that period. Engineering departments of machine tool builders have been called on to perform the colossal task of eliminating models not vitally essential, of refining standard machines to take care of higher production, and of designing innumerable special-purpose machines for filling the needs of the defense program. Defense work formerly requiring several machines to produce can now, in many cases, be carried out more or less automatically on one special-purpose machine in considerably less time, thus not only cutting down the number of operators required but increasing production by several hundred per cent.

Let us hope that all other industries connected in any manner with the defense program—and the number is being increased daily—will take a leaf from the book of the machine tool industry. Elsewhere in this issue reference is made by a contributor to progress that has been made in the American way —not by compulsion! The machine tool industry, and particularly its designers, gives a shining example of this which might well be emulated throughout the nation.

Hydraulic Drives

NO TYPES of drive, reciprocating or rotary, have incited more interest among designers during recent years than those carried out by means of hydraulics. Better proof of this, if needed, could not be found than in the reception accorded the article written by Christian E. Grosser which appeared in the December issue, "Hydraulic Control Affords Design Flexibility."

Readers will be interested to hear that the next article on this subject (another in the series to be published at frequent intervals) will appear in April. This second article is included among those scheduled for the "Machine Drives and Controls" supplement which will form part of the regular April issue of MACHINE DESIGN.

Professional Viewpoints

MACHINE DESIGN welcomes comments from readers on subjects of interest to designers. Payment will be made for letters and comments published

" . . . tests show increased strength"

To the Editor:

Mr. Kehl's cautions in your January issue about using shot blasting are timely in calling attention to designers not to expect a millenium. However, he did convey one idea which was not correct by intimating that only one test gave 42 per cent increase. On many hundred tests we obtained the same thing. With proper shot blasting over the last five years, valve spring wire has commercially done this. Other materials respond according to their metallurgical background.

Regarding embrittlement by excessive shot blasting the remarks are logical. We have not, however, noticed any such conditions for time intervals four to six times longer than that necessary to develop maximum endurance properties. The use of carburizing for parts would have the same criticism—you could carburize enough to ruin the piece, but carburizing is one of our useful processes.

On torsion bars, axles, crankshafts, connecting rods and other parts we have seen tests on, there has been in all cases an increase in endurance. Torsion bars in particular gave a better account of themselves when shot blasted than after grinding and polishing.

This process will not cure metallurgical defects or poor design. Properly applied, however, it is a helpful new tool for industry.

—F. P. ZIMMERLI
Barnes-Gibson-Raymond

" . . . applying proper motors"

To the Editor:

Mr. Drake's article "Selecting Special Motors" in your January issue re-establishes one's faith in the democratic way. It illustrates how the electric motor industry has joined hands with the machinery builders to develop a more useful and efficient unit. The first shaftless motors, for instance, are a far cry from the present designs built into pressed steel shells.

Perhaps the advances made in applying the proper motor to the job warrant speculation as to the future. It is possible to visualize a line of induction motors with the rotor on the outside of the stator. That is, the squirrel-cage rotor would be annular so that it could be pressed into the part it is to drive. This construction might be useful, for instance, in driving gears or drums.

Another type of induction motor that might be seen more generally is the spinner motor invented years ago. In this motor the above-described construction is amplified by supplying two squirrel cage rotor windings on the annular laminations. Then this complete motor is put into a second stator. Thus this two-winding squirrel-cage rotor is affected by two fields with resultant shaft speeds that are different from conventional sixty-cycle speeds. Also, much greater flexibility in multispeed motors results.

However, a great deal of time could be saved if industry could procure a completely round motor, supplied with switch blade contacts instead of leads. To replace such a motor it would only be necessary to loosen some holding nut and pull the motor and gear right out. Another motor could be slipped into place.

One can be sure that more time will be given to developing self-cleaning motors, using sealed ball bearings, removable stators, and simpler assemblies.

But that is for the future. In the meantime we should be thankful we can point to the success obtained through co-operation, and not by compulsion.

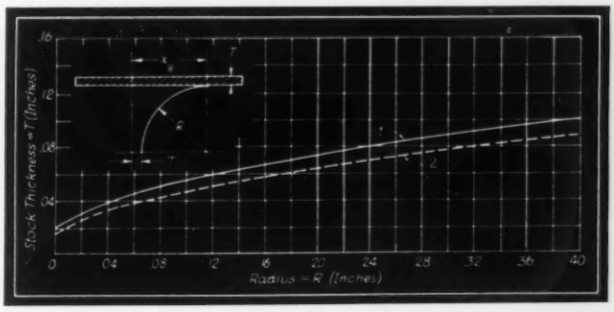
—G. A. REINHARD
Cleveland, Ohio

" . . . designing minimum bends"

To the Editor:

In designing U-shaped sections that are to be manufactured on a power press, the accompanying chart furnishes a quick reference for the minimum length of leg. Although the chart may be classified as tool

(*Concluded on Page* 136)



Applications
of Engineering Parts and Materials

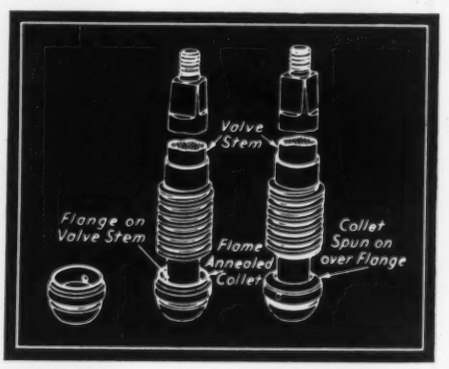
Agitator Resists Corrosive Attack

CONSTITUTING one of the largest phenolic resin moldings made in this country, the washing machine agitator illustrated was developed by the Bakelite Corp. In addition to the lighter weight and consequent reduced inertia over the previous metal agitators, inertness to boiling water, soap and mild alkali insures a permanently smooth and clean surface. The agitator shown is that of the Barton Corp.

Permanently smooth surface is maintained by Bakelite agitator

Annealing Permits Rolling of Valve Disk

ABILITY of the monel casting alloy, S-Monel, to be spun or rolled in its annealed condition makes possible the unique assembly of the disk to the stem in the illustrated locomotive valve. The usual method of assembly by means of screw threads or keyways has a tendency to weaken small disks. Heat treatment of the disks to a hardness of 325 to 350 brinell augments the characteristic resistance of this material to corrosion and galling. Localized flame annealing is then applied to the collet section, raising its temperature to 1600 degrees Fahr. after which it is quenched in water. The softened collet can then be rolled over the stem, providing self-alignment with the seat and permitting the stem to rotate within the disk.

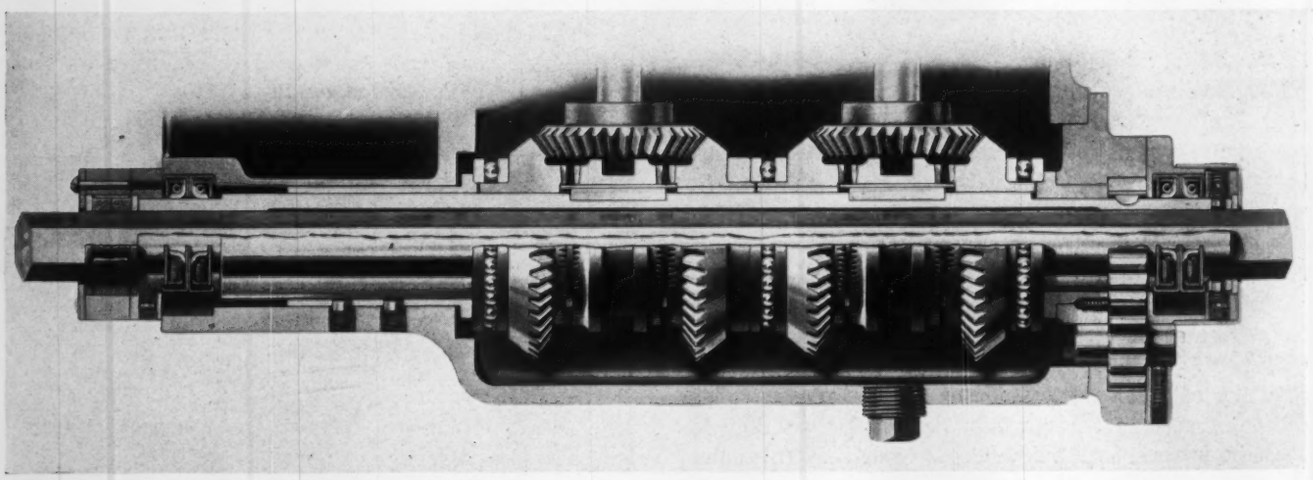


Valve disk of S-Monel is attached to the assembly above by rolling collet

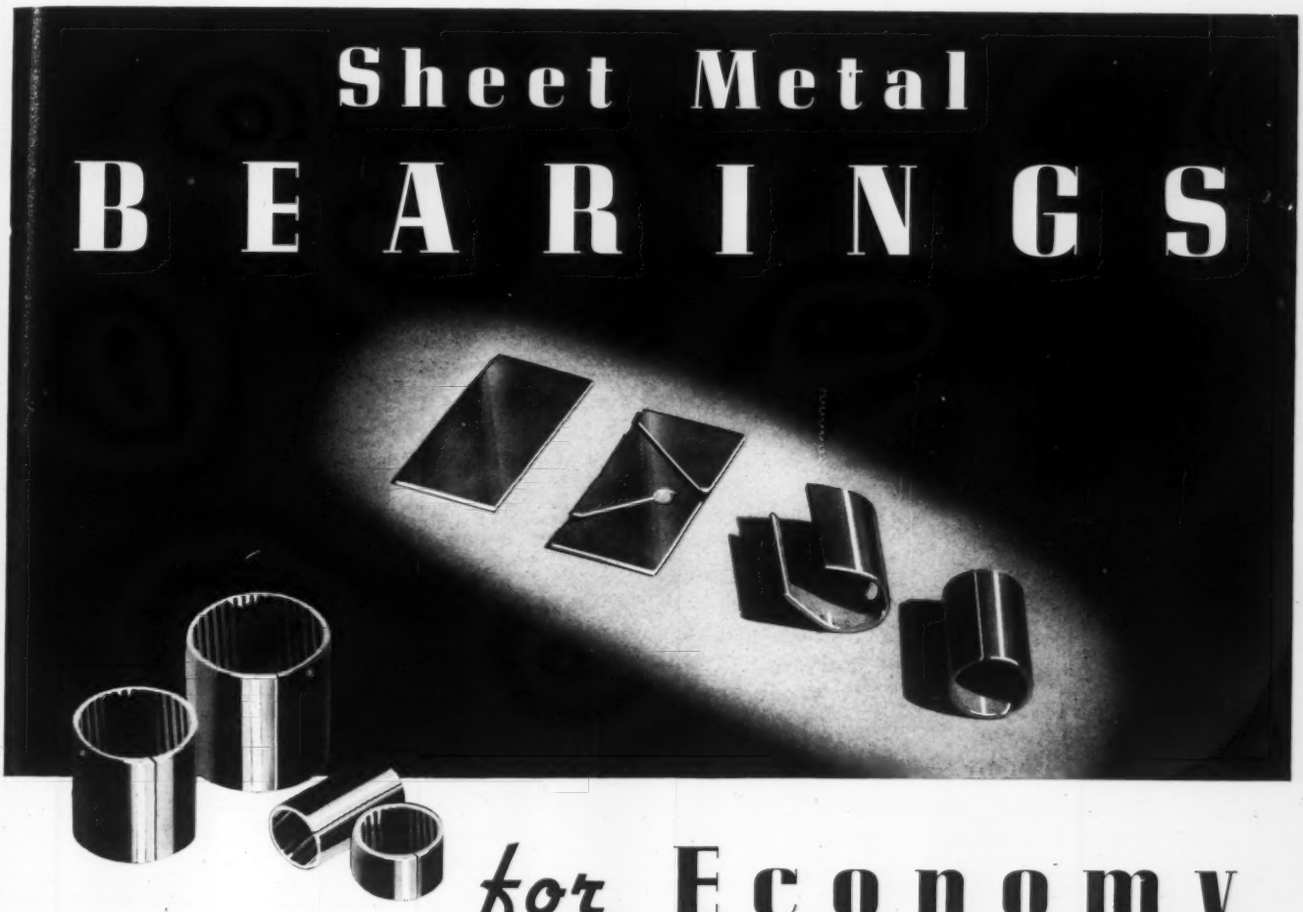
Broached Bronze Sleeve Eliminates Keys

USE of a hexagonal traverse shaft eliminates the necessity for traverse keys in the Gisholt turret lathe apron illustrated. A hexagonal hole is broached in the Ampco metal sleeve which rides on the shaft. This bronze sleeve carries all the traverse gears, clutches and bearings in the assembly and is protected against the entrance of coolant or escape of lubricant by opposed oil seals mounted at each end. Due to the sleeve mounting of the gears, any coolant or dirt adhering to the traverse shaft passes through the apron and cannot enter the oil chamber.

Below—Ampco bronze sleeve serves as gear and clutch carrier



Sheet Metal BEARINGS



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Men of Machines

JOSEPH B. ENNIS

FOR many years vice president in charge of engineering of American Locomotive Co., Joseph B. Ennis has become senior vice president. He is also a director of the company.

Born at Wortendyke, N. J., in 1879, Mr. Ennis began his career as a tracer in the drafting room of Rogers Locomotive Works, subsequently becoming detail draftsman and elevation draftsman. He then joined the Schenectady Locomotive Works in the same capacity, and from 1900-1901 was draftsman at Rogers Locomotive Works. The next year he occupied a similar position with the Cooke Works of American Locomotive Co., and later was transferred to the New York office in charge of designs and calculation-specifications for locomotives. In 1906 he was appointed assistant to mechanical engineer; in 1908 designing engineer; in 1912 chief mechanical engineer; and in 1917 vice president in charge of engineering.

C. C. HERMANN

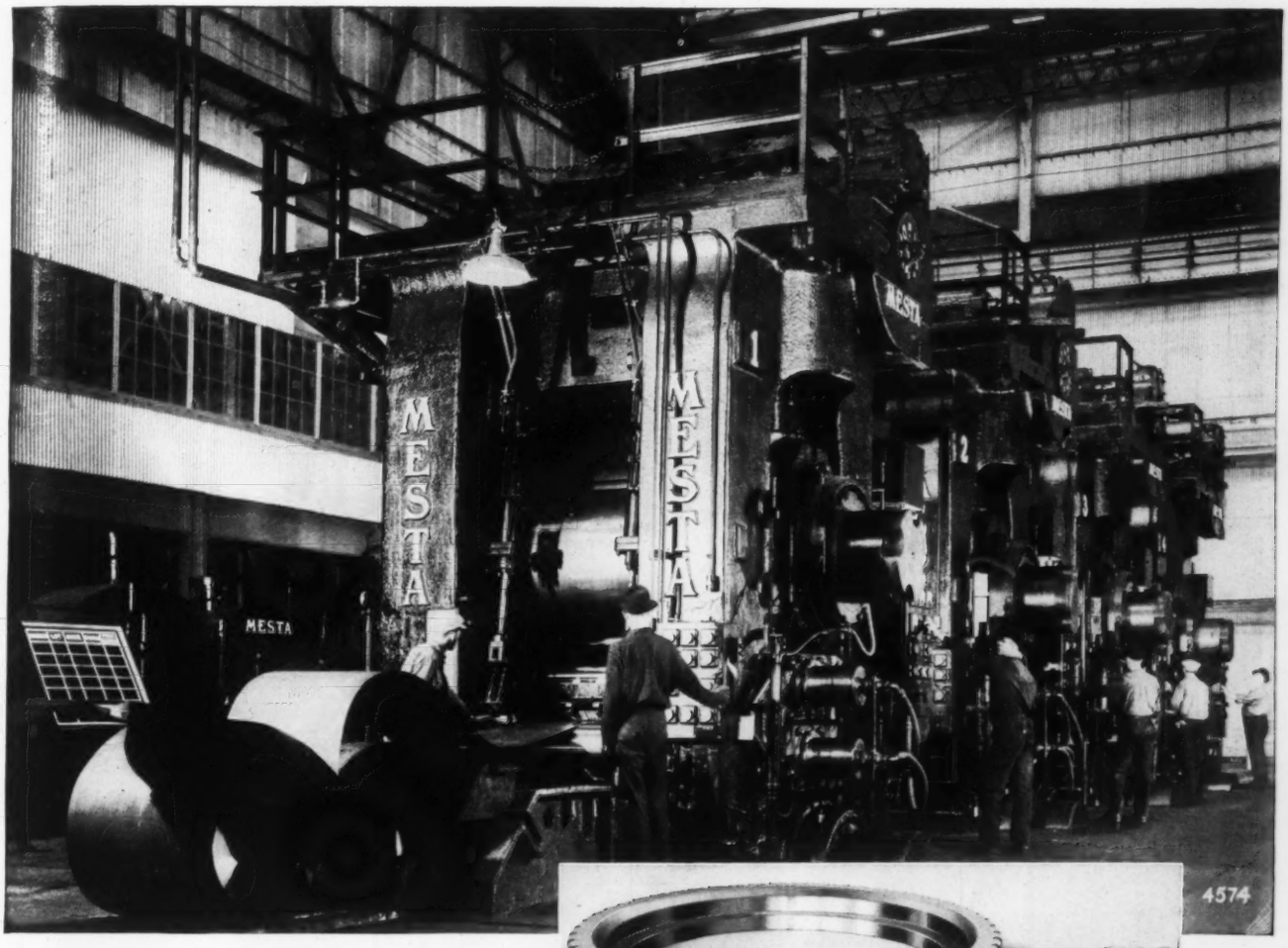
C. C. HERMANN, well known to the engineering profession, has become chief engineer of the Claude B. Schneible Co., Chicago, designers and manufacturers of dust collection machinery and allied equipment. Mr. Hermann has been connected with the organization since 1937, having been in charge of the Philadelphia office as sales engineer.

Previous to his association with this company he was a member of the engineering department of Deere & Co., Moline, Ill., manufacturers of agricultural implements. He also had been associated with John Deere Tractor Co., Waterloo, Ia., as plant engineer. Mr. Hermann has been a liberal contributor to engineering journals and to the trade press during the past twenty years, and being a mechanical engineer is a member of the Universal Craftsmen's Council of Engineers, the American Foundrymen's association, and other engineering organizations.

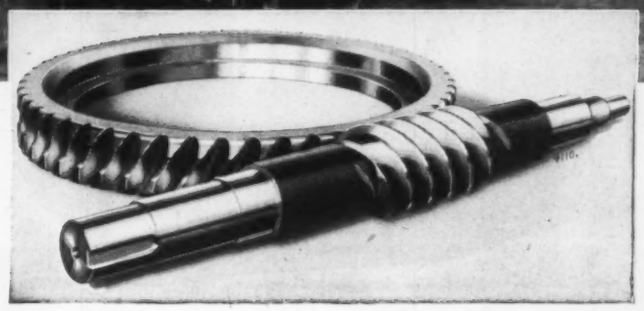
PHILLIP B. TAYLOR

COMING up through the ranks, including the engineering department, Phillip B. Taylor was recently appointed assistant general manager of Wright Aeronautical Corp., Paterson, N. J.

Born in New York city, March 7, 1899, Mr. Taylor attended schools at Montclair, N. J., later entering the Sheffield Scientific School of Yale university from which he was graduated in 1920. In order to prepare himself for his career, he did odd jobs during his high school and college terms, one of his connections being with the International Arms and Fuse Shop. In 1916 he was a machinist with Worthington Pump Co., while two years later he worked as a test engineer at the Aero Engine Laboratory at the Washington Navy Yard, and in 1919 as machinist with the Jenkens Mfg. Co. Again as a machinist, he became connected with E. W. Bliss and in subsequent years he worked with Morgan Construction Co. and American



Feeding strip steel from coils into 54 in., four high, four stand, tandem cold rolling mill; screwdowns operated by De Laval Worm Gear Sets.



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meet varied speed transformation requirements and, because of compactness, right-angle drive, and great range of ratios, often permit of marked simplification and improvement of machines in which they are incorporated. The designer receives not only the benefit of specialized manufacturing equipment and methods developed through our many years in the manufacture of high grade speed reducers, but he can also draw upon our extensive experience with a great variety of speed reducer applications.

The De Laval engineers will gladly submit data and recommendations upon learning of proposed plans and requirements.

Ask for Catalog W 1121

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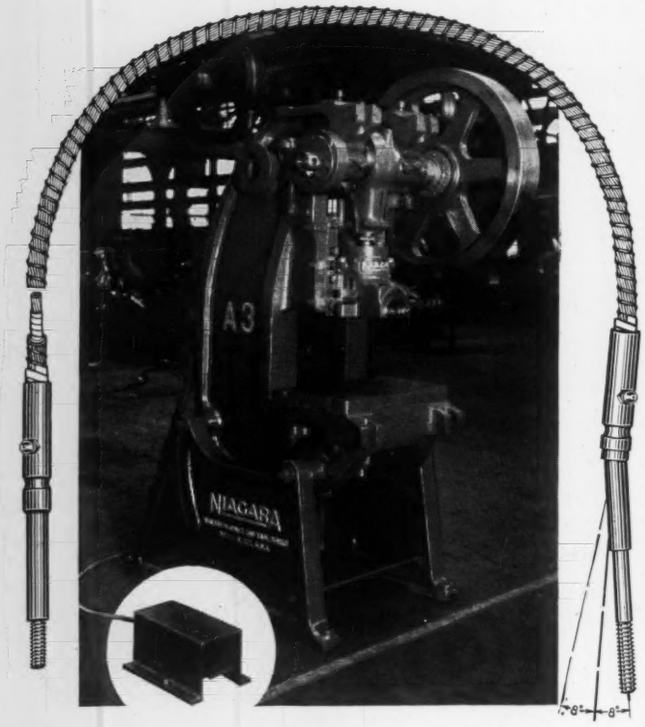
of the De Laval Steam Turbine Co., Trenton, N. J.



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AMERICAN CHAIN & CABLE COMPANY, Inc.

Steel & Wire Co. In June 1922 Mr. Taylor came to Wright Aeronautical Corp. as a test engineer and was rapidly promoted to higher ranking positions until he became chief engineer, and recently assistant to the vice president-general manager of the corporation.

♦

JOSEPH L. TRECKER, vice president, and FRANCIS TRECKER, assistant chief engineer of Kearney & Trecker Corp., Milwaukee, have left for Washington to serve as "dollar a year" men for the war department. This company is said to be one of the first to initiate the practice of farming out contracts for the manufacture of machine tools. It is expected the Treckers will become special advisers in the distribution of arms contracts to small firms.

♦

DR. EDWARD E. MINOR JR. has been appointed chairman of the new Air Transportation committee of the American Institute of Electrical Engineers. Dr. Minor is research and development engineer of The Glenn L. Martin Co., Baltimore.

♦

CHARLES F. SEELBACH has been elected vice president and trustee of the Gray Iron Research Institute Inc., Columbus, recently formed to engage in research and development work on gray iron. Mr. Seelbach is vice president and general manager of Forest City Foundries Co., Cleveland.

♦

DR. WILLIAM A. MUDGE has joined the staff of the technical service division of the New York office of International Nickel Co. Inc. For the past seventeen years, Dr. Mudge has been superintendent of research, superintendent of the refinery and works metallurgist at the company's rolling mill at Huntington, W. Va.

♦

PAUL H. RUTHERFORD, formerly chief engineer at Delco Products division of General Motors Corp., has been appointed factory manager. EDWIN F. ROSSMAN, assistant chief engineer, has succeeded Mr. Rutherford as chief engineer, and CALVIN J. WERNER has been moved up to assistant chief engineer.

♦

RALPH DE PALMA, former racing driver, has joined the staff of the National Aeronautics council which was recently organized for the purpose of training young men and women for aviation careers.

♦

E. W. ENGSTROM has been appointed manager of all research activities for the RCA company. He became connected with the organization in 1930 as an engineer in the photophone division, and later was appointed director of general research.

♦

HOMER B. WEST, since 1935 in charge of Westinghouse Electric & Mfg. Co. instrument and regulator engineering, has been made manager of manufacturing in the transformer division of the company's of-

BRUNING "75" PRINTER AND 154 BW DEVELOPING MACHINE

These two machines will provide the high efficiency print production to gear your print department to today's needs. One man can develop 1200 8½ x 11 BW Prints per hour, and two men can develop 2600 8½ x 11 BW Prints per hour.

The Bruning booklet, "New Light On Prints," fully describes the "75" Printer and the Model 154 Developer, and gives information about other Bruning printers and developers. Send for your copy.

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● A "jam" in the print department is transmitted all along the line . . . delaying poduction and shipments. That's one reason so many firms are turning to Bruning Black and White (black line) prints . . . the prints which are produced in a fraction of the time and often at lower cost than blue prints.

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OHIO GEARS

fice at Sharon, Pa. Mr. West's inventions while with Westinghouse have contributed notably to the design of modern power distribution transformers. He joined the company in 1919 in its power engineering department.

♦

GERALD A. LUX has resigned as technical director at Lustre Chemical Corp. to accept the appointment as research associate of American Electroplaters' Society at the National Bureau of Standards.

♦

E. R. MERTZ has been named teaching specialist in forge practice in the mechanical engineering department of Stanford university, California.

♦

ANTHONY WILLIAM DELLER has been named patent counsel for The International Nickel Co. He is a patent attorney and lecturer on patent law at Columbia University's School of Engineering.

♦

JACK F. WOLFRAM has been appointed assistant chief engineer in charge of engine, transmission and axle design at the Oldsmobile division, General Motors Corp., Lansing, Mich. He was formerly experimental engineer. Heretofore chassis engineer, MAURICE A. THORNE becomes assistant chief engineer in charge of body, chassis, electrical and accessory groups. JOHN OSWALD, since 1929 body engineer, has become director of styling.

♦

DR. G. H. MCINTYRE, director of research, Ferro Enamel Corp., has been appointed chairman of the committee on the research associate at the national bureau of standards.

♦

MASON BRITTON has been appointed director of the Machine Tool and Heavy Ordnance division of the National Defense Advisory commission, succeeding HAROLD VANCE who has returned to active duty at the Studebaker Corp.

♦

JAMES S. DICKIE, who has been with the American Shipbuilding Co. for twenty-four years, has been elected vice president in charge of engineering.

♦

EDWARD BARTOW has recently become associated with the Johns-Manville Corp. in its research laboratory at Manville, N. J.

♦

E. O. SHREVE has been appointed president of the National Electrical Manufacturers association. Mr. Shreve is vice president in charge of apparatus sales of General Electric Co.

♦

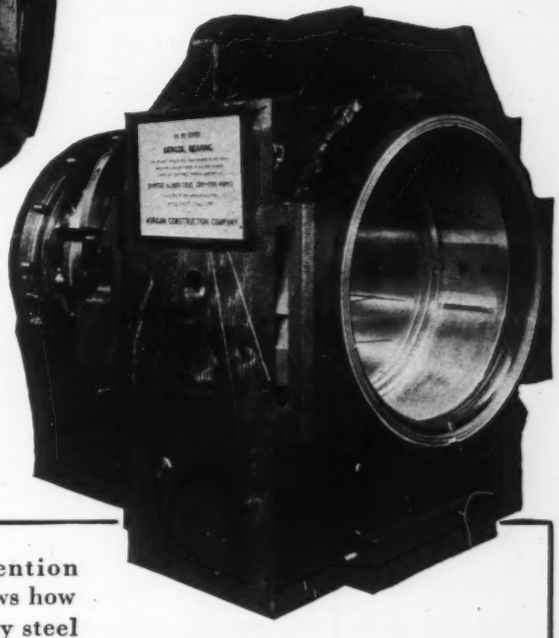
CARL H. LAMBELET has been elected president of the Packaging Institute Inc. He is president of the New Jersey Machine Corp. At the membership meeting of the Packaging Machinery Manufacturers institute, which operates as the machinery division of the Packaging Institute Inc., the following officers were elected: Carl H. Lambelet, president; Morehead Patterson, American Machine & Foundry Co., and Charles L. Barr, F. B. Redington Co., vice presidents.

5,000,000 POUND LOADS...

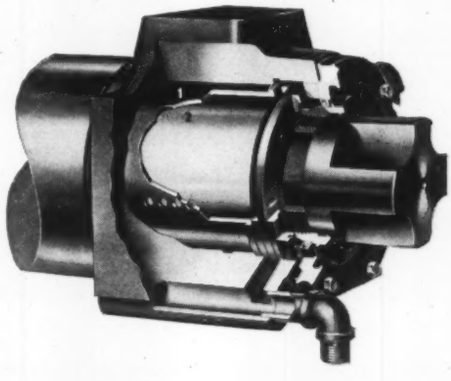
...yet *these* bearings *stand up!*

NICKEL

ALLOY STEELS



Bearings must take terrific poundings in high-speed rolling mills. This 44 in. bearing sleeve safely withstands pressures above 5,250,000 lbs. After years of research and experience, the MORGAN CONSTRUCTION CO., has standardized on Nickel-molybdenum steel for roll neck bearing sleeves. Nickel alloy steel retains its finish and maintains alignment.

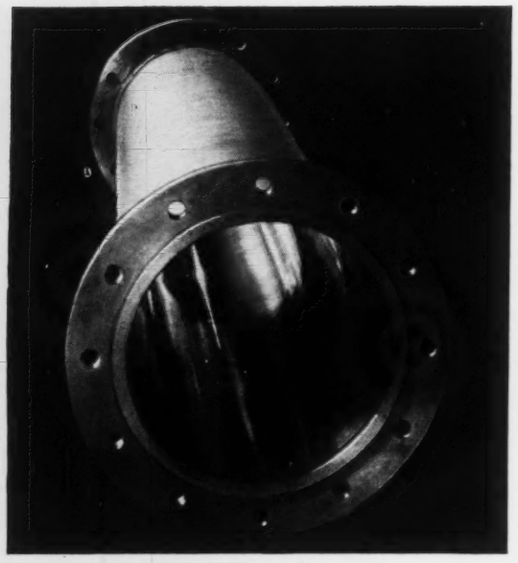


This convention exhibit shows how Nickel alloy steel MORGOIL bearing sleeves are mounted for high speed operation in a continuous strip mill. Production economies and increased output naturally follow the increased abilities of tougher Nickel alloyed materials.

Diagram showing the ASARCOLOY bushing (marked 1) which backs up the Nickel alloy steel bearing sleeve (marked 2). Asarcoloy is a cadmium Nickel material with a very low coefficient of friction.

Confronted by tougher production schedules this year, don't get caught with your bearings down. Avoid breakdowns by specifying bearings strengthened and toughened by Nickel alloyed materials. Helpful, practical advice on efficient bearing metals and mountings is available promptly upon your request to:

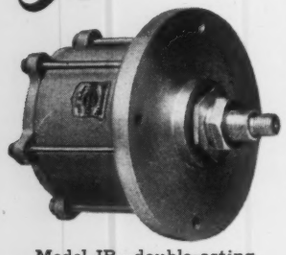
THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.



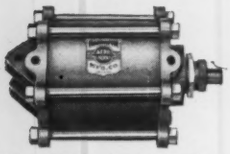
16 in. x 7 ft. honed cylinder

BETTER CYLINDERS FOR BETTER USE OF *Air Power*

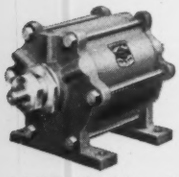
Hannifin Pneumatic Cylinders combine features of design and performance that assure better use of air power—no leakage, minimum friction loss, full power devoted to useful work.



Model JR—double-acting air cylinder



Model BR—double-acting air cylinder



Model CR—double-acting air cylinder

Hannifin Cylinders, including even the largest sizes, are bored and then honed. The cylinder interior thus produced is straight, round, and perfectly smooth. Hannifin outside adjustment of the piston packing allows easy maintenance of high efficiency piston seal. The soft, graphite-treated piston packing, easily kept in correct adjustment, prevents leakage and means minimum friction loss. The piston can be repacked, in an emergency, with ordinary graphited packing, always available. No special parts are required.

Hannifin Pneumatic Cylinders are built in a full range of standard mountings, 1 to 16 in. diameter, for any length stroke. Both single and double-acting types, with or without air cushion. Write for Bulletin 34-MD with complete data.

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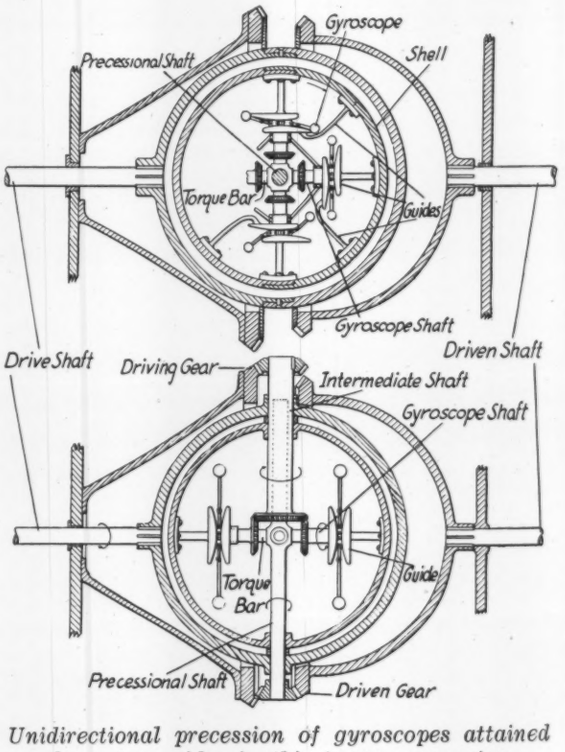
HANNIFIN
PNEUMATIC CYLINDERS

Noteworthy PATENTS

Torque Converter Utilizes Gyroscopes

ADAPTABLE to any desired torque and speed relationship, the torque converter and variable speed transmission illustrated provides a transmission for automobiles with speed control from zero through overdrive without change gears. The patent, issued to E. A. Stalker, eliminates clutching in forward speeds without necessitating the incorporation of an overrunning clutch. It should have extensive application also in power drives where specific torque-speed relationships are essential.

Directly connected to the prime mover, the drive shaft rotates the spherical housing to which it is splined. The intermediate shaft journalled in this housing, and also the shell, are thus turned by the

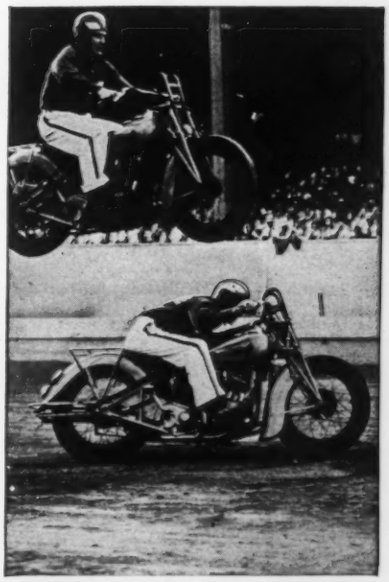


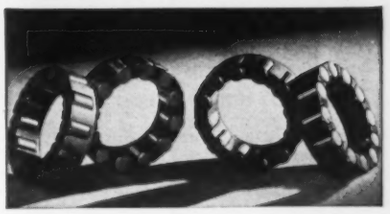
Unidirectional precession of gyroscopes attained by rotor guides in this torque converter

driving gear which engages a fixed bevel. The gyroscopes are thus rotated by the turning of the gyroscope shafts, each of which carries a bevel gear. Concentric with the gyroscope shafts are four torque bars which serve to transmit the gyroscopic thrust to the precession shaft. The outer end of this latter

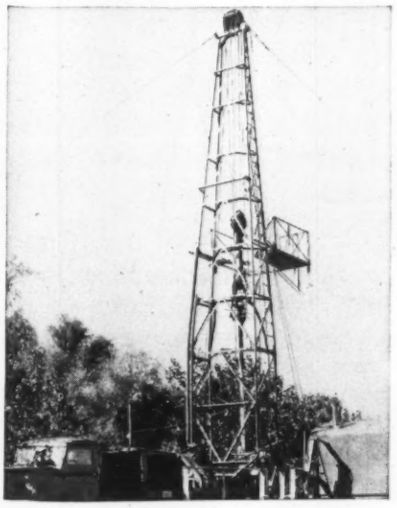
In the News
WITH BANTAM BEARINGS

UNIQUE ENGINEERING FEAT is the pontoon-supported Lake Washington Bridge at Seattle—longest floating bridge in the world, first of its type to be built of reinforced concrete. Striking feature of the novel structure is the movable span which slides back into a U-section to permit passage of large steamers. Insets show span in open and closed positions. Guide rollers keep movable span in horizontal and vertical alignment. Specially designed Bantam Tapered Roller Bearings for vertical guides measure 10½" I.D., 16"O.D., 2⅛" thick, are rated at 331,000 pounds at 14.3 RPM. Horizontal guides use 8 Bantam Straight Roller Bearings, 10" I.D., 15¾" O.D., 6⅛" thick.

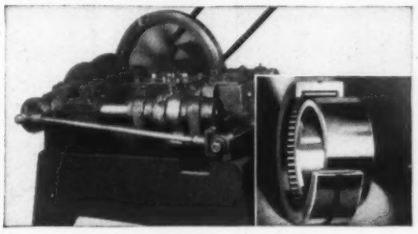




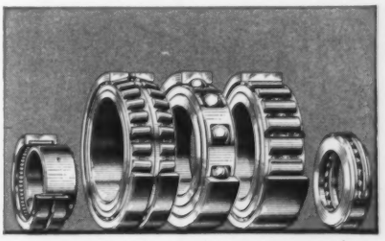
A FLYING MOTORCYCLE LEAP calls for plenty of stamina in the machine—and so does normal operation at high speeds over rough roads. Bantam designed special roller bearings to meet the requirements of long life and accurate tolerances—and Indian Motocycle Company installed them at 14 vital points on its 40-horsepower Indian 74.



OIL FIELDS PAY OUT when they use Franks Mfg. Corporation's drilling rig, which travels around, derrick and all, on a single truck. Low drilling costs make it profitable to work poorer paying fields. Since low-cost operation is keynote of the rig, Franks selects Bantam Bearings for rotary table and swivel. Bantam Bearings efficiently serve the makers and users of every type of oil field equipment.



WIRE NAIL MACHINE built by Wm. Glader Machine Works, Chicago, is subjected to frequent severe impact loads. Bantam's Quill Bearings are used on actuating roller. This compact antifriction bearing is high in capacity, low in cost, easy to assemble. For full information on the Quill Bearing, write for Bulletin B-104.



EVERY MAJOR TYPE OF ANTI-FRICTION BEARING is included in Bantam's line—straight roller, tapered roller, needle, and ball. Bantam serves every industry with a wide range of *standard bearings*—and Bantam engineers design *custom-built bearings* in large sizes and special types for unusual applications. If you have an exceptionally difficult bearing problem, TURN TO BANTAM.

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

● The saving of one second in a 5-second work cycle means a 20 per cent increase in a machine's productive capacity.

For example: A slight lag in the clutch release . . . the inefficient spacing of the friction plates . . . the design of the clutch operating mechanism, might easily retard your machine's productiveness by 20 per cent . . . bottle-neck its ability to turn out work at maximum speed.

The main reason why machine tool builders continue, year after year, to standardize on Twin Disc Machine Tool Clutches is because Twin Disc Machine Tool Clutches are "built for the job" . . . built to accelerate production, not to bottle-neck it.

The complete range of sizes, from 3 inches to 12 inches, allows you to choose a standard unit that will not only fit into the design of your machine tool, but also assure maximum clutch efficiency. Ask for specific recommendations.

BOTTOM: *Twin Disc Model MT Single Machine Tool Clutch.*

BELOW: *Twin Disc Model MT Duplex Machine Tool Clutch.*

TWIN DISC CLUTCH CO. • 1325 RACINE ST. • RACINE, WIS.

shaft carries a bevel gear through which the driven gear is turned, rotating the driven shaft.

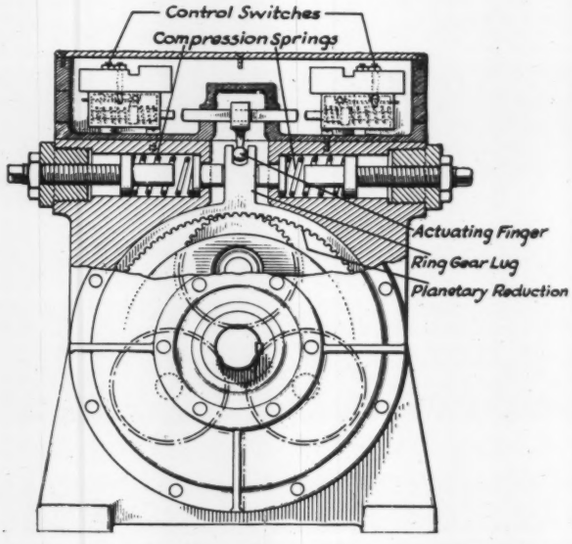
In order to avoid the reversal of precessional torque for each 180-degree rotation of the shell, guides are used on each side of the gyroscopic segments so that these segments exert their full driving force only on one side of the precessional axis.

Utilization of gyroscopic action is attained by the use of a fourth axis about which the segments rotate. This is the hinge pin through the supporting arm of each segment.

Since the rate of precession is a factor in the speed of rotation of the gyroscopes, the driven gear, at high speeds, will rotate faster than the driving gear assuming that the torque load reduces to maintain a fairly constant power output at all speeds. At low speeds, maximum torque is delivered.

Control Protects Drive

DESIGNED to protect a prime mover from excessive loads, the unit illustrated is effective for both forward and reverse rotation. In this patent, assigned to the Philadelphia Gear Works, a conventional planetary transmission includes a normally



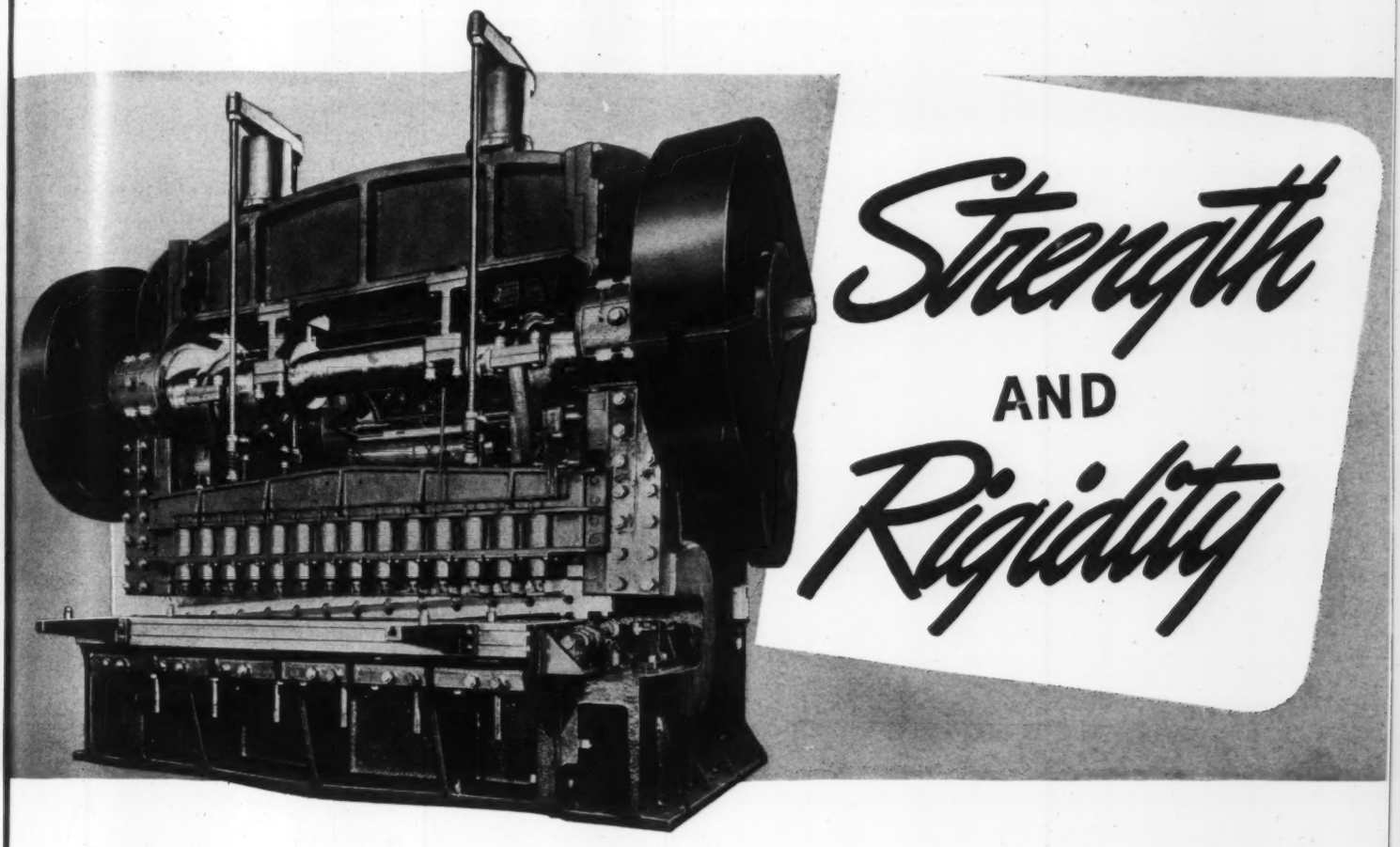
Overload control for planetary gear head protects driver for either direction of rotation

stationary internal ring gear, three planets, and a sun gear mounted on the drive shaft. The planets are mounted in a cage keyed to the driven shaft.

Instead of the customary rigid mounting of the ring gear in the housing, this gear is formed to a running fit so that the reaction of the planets in driving tends to produce a nominal rotative motion of the ring. On the outer periphery of the gear a ring gear lug is formed which is constrained between two compression springs. Adjustable by means of set screws, these springs oppose the tendency toward rotation of the ring gear as a result of torque reaction of the load.

Held in a fork in the lug is a control switch ac-

1/2 MILLION POUNDS OF



World's largest press made of Steel Castings

This recently built Plate Shear, built for a large steel mill, is said to be the largest machine of its type ever constructed. It will shear plates up to 162 inches wide, and up to 2½ inches thick, at one stroke. The machine weighs over half a million pounds.

Obviously such a huge machine, built for such heavy duty, demands the maximum in strength and rigidity. The builder writes us: "Cast Steel has been used throughout because of its proved strength and rigidity, which are so necessary in a machine of this type."

And yet Cast Steel is an equally suitable material for parts weighing only a pound or two. It is industry's most adaptable material. It permits scientific streamlined weight distribution without excess weight, with maximum strength exactly where it is most needed. It permits combinations of parts in a single casting, saving on finishing, fitting and assembly time. And a wide range of mechanical properties are available to meet all operating conditions.

Whether your products are large or small, you can doubtless use more steel castings, and benefit from these important advantages. Steel castings are the modern material for mechanical construction—efficient, dependable and economical.

Why not consult your local foundryman and get his recommendations? Or you may write, without obligation, to Steel Founders' Society, 920 Midland Bldg., Cleveland, O., where you may draw upon a broad fund of practical experience.

MODERNIZE YOUR PRODUCT WITH

STEEL CASTINGS

TRACING CLOTH
MUST HOLD AND PROTECT
THE BEST IDEAS OF
HIGHLY TRAINED MEN

OUR TRACING CLOTHS
ARE MADE TO BE
WORTHY OF THIS
IMPORTANT TRUST

Clear As Crystal
AND STAYS THAT WAY!

It's not original but *lasting* transparency that determines the true worth of tracing cloth. Remember, oil will make even wrapping paper temporarily transparent – so don't be fooled by "just as good" tracing cloths. They look fine the day you buy them, but are transparent as stove lids a year later.

The permanent transparency of Arkwright Tracing Cloths comes from special mechanical processing – not from surface oils that make the cloth become brittle and opaque with age. Arkwright Tracing Cloths will be as clear years later as they are the day you buy them. And you'll get the same clean, "snappy" blueprints, free from specks caused by dirt, stains, or pin holes.

Remember, next time you order tracing cloth, you're buying for tomorrow as well as today. Specify Arkwright! Arkwright Finishing Company, Providence, Rhode Island.

Arkwright
TRACING CLOTHS

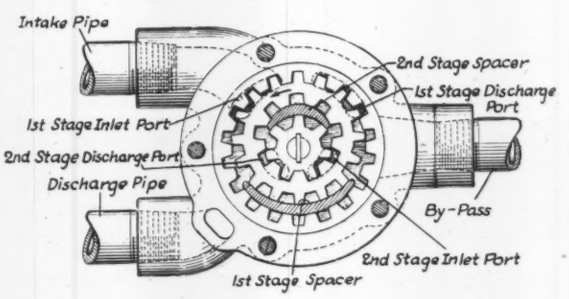
tuating finger. When the driven load increases so that the reaction on the ring gear is sufficient to overcome the set load of the compression spring, one or the other of the control switches is actuated. The control switches may actuate a signal or may energize a pilot circuit disconnecting the prime mover from the line.

As shown in the illustration, the control is effective for either direction of rotation. Also, by adjustment of the set screws, the maximum torque load which will occasion tripping of the control switches is adjustable independently for each rotative direction and need not be the same in both cases.

Gear Pump Has Two Stages

DESIGNED primarily for handling fuel oil for pressure type oil burners, the pump shown in the drawing has many advantages including few moving parts and manufacturing economy. It also is self-priming and capable of sustaining high pressure heads. Patent is assigned to Webster Electric Co.

Pump elements consist of only three moving parts, an internal ring gear, an intermediate gear with



Both stages of fuel pump are driven by center pinion. Spacers permit eccentricity of impellers

teeth formed on both its inner and outer periphery and a driving spur gear. The driving shaft, which is sealed in the housing at the rear by a shaft seal, carries the central driving spur gear keyed to it. This gear provides the drive for both the stages of the pump through the intermediate gear.

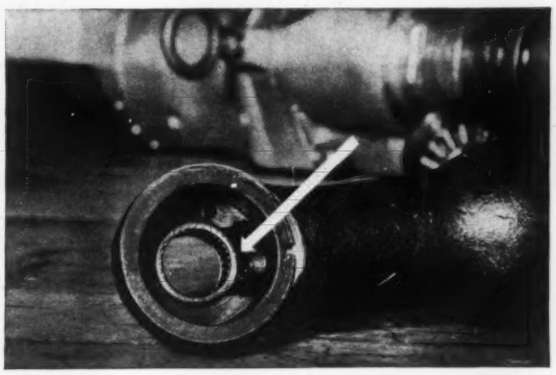
The internal ring gear and the outer teeth of the intermediate gear constitute the first stage. This stage discharges into a reservoir not shown in the illustration but located in the pump housing behind the impellers. The by-pass line runs from this reservoir back to the storage tank. The second stage draws oil from the reservoir through its inlet port and discharges it against the pressure head through the discharge port.

Abrasives Projected Electrically

SHOTBLASTING of parts to produce cleaning, abrading or surface refinement is accomplished by the illustrated abrasive projector by means of a

(*Continued on Page* 90)

CHICAGO PNEUMATIC CUTS SIZE AND WEIGHT OF ANGLE HEADS WITH TORRINGTON NEEDLE BEARINGS



1 "The small size of Torrington Needle Bearings permits substantial reduction in dimensions of our Angle Head tools," declares J. E. Olson, engineer of Chicago Pneumatic Tool Company. The anti-friction Needle Bearing (shown above in an Angle Head housing) occupies no more space than a plain bushing.

2 Torrington Needle Bearings are self-contained units easily installed in even the simplest types of housing. Precision ground rollers are retained in a hardened outer race to form a compact unit that is surprisingly low in cost. Savings in assembly time and labor give additional production economies.

3 Needle Bearings at points indicated are inaccessible to ordinary lubrication when shaft is assembled in housing. "But they require no extra lubrication systems," say Chicago Pneumatic engineers, "because large supplies of grease are retained within the close-fitting, turned-in lips of the race."

4 The Angle Head's purpose is to work in tight places. It fits into these close quarters with the aid of Torrington Needle Bearings which afford large reductions in bulk and weight of surrounding material, yet have ample capacity for carrying heavy loads at high speeds with greater efficiency and longer life.

Are you seeking ways to improve your product's efficiency while keeping costs and space requirements low? The Torrington Needle Bearing may be the solution of your problem. Our Engineering Department will gladly help you plan the inclusion of the

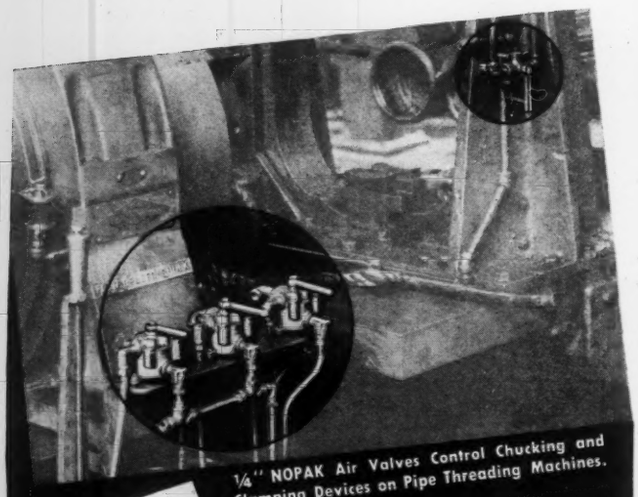
Needle Bearing's advantages in your product. For more detailed information, write for Catalog No. 109. For Needle Bearings to be used in heavier service, ask our associate, Bantam Bearings Corporation, South Bend, Indiana, for a copy of Booklet 103X.

THE TORRINGTON COMPANY, TORRINGTON, CONN., U. S. A. • ESTABLISHED 1866

Makers of Needle and Ball Bearings

New York Boston Philadelphia Detroit Cleveland Chicago London, England

TORRINGTON NEEDLE BEARING

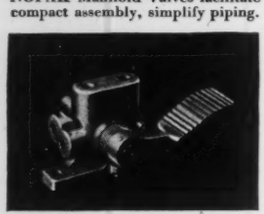


¼" NOPAK Air Valves Control Chucking and Clamping Devices on Pipe Threading Machines.

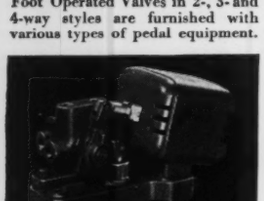
Precision Valve Control for AIR or HYDRAULIC MOVEMENTS...

3- and 4-way Hand Operated Valve for single or double-acting cylinders.

NOPAK Manifold Valves facilitate compact assembly, simplify piping.



Foot Operated Valves in 2-, 3- and 4-way styles are furnished with various types of pedal equipment.



NOPAK 3- and 4-way Solenoids are used where automatic or remote control is needed.

Build it into Your Machines with NOPAK 3- and 4-Way Operating Valves

THE NOPAK flat-disc principle, basic patented feature of all NOPAK Valves, is primarily responsible for the fine degree of control which they provide.

The flat-disc design permits advantageous port spacing which results in positive, accurate control thru the full range of valve manipulation. From slow, gradual throttling action to instantaneous opening under full pressure, NOPAK Control Valves produce the exact cylinder action required.

Throttling action does not result in pressure-cutting or injury to valve seat or disc. Actually, the perfectly lapped seal between disc and seat improves with use, and is permanently shielded from grit and foreign matter. *Packless construction* eliminates stem leakage, gland-nut attention and packing maintenance.

Specify NOPAK Valves for precision control plus "lifetime" protection against valve maintenance expense. Our engineers can show you how to use NOPAK Valves to greatest advantage in the solution of your control problems.

GALLAND-HENNING MFG. CO.
2752 S. 31st Street, Milwaukee, Wisconsin

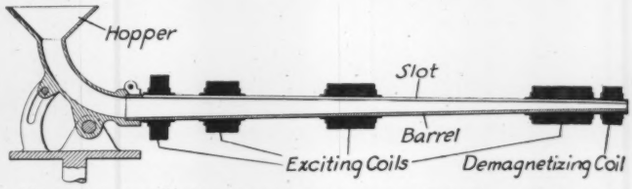
NOPAK VALVES and CYLINDERS
DESIGNED for AIR or HYDRAULIC SERVICE

A 3315-½

(*Continued from Page* 86)

pulsating magnetic field. Metallic particles are used such as steel grit or shot. The patent, assigned to The American Foundry Equipment Co., claims the use of either polyphase alternating current or direct current to produce the field impulses. The device may have a capacity of 300 pounds per minute at a velocity of 12,000 feet per minute.

As illustrated, the gun is designed to utilize 3-phase alternating current. Four sets of exciter coils



Abrasive projector having four accelerating stages is adaptable to various particle speeds by varying the relative position of the coils

consisting of three sections each are spaced along the barrel at increasing distances toward the muzzle. Each of the three sections of each of the coils is connected to one line of the 3-phase circuit. Thus, four separate accelerating impulses are given to the particles as they travel along the tube. Gravity flow from the hopper provides a modicum of initial velocity which may or may not be supplemented by a mechanical impeller.

Spacing of the exciting coils determines the final velocity. In general, the greater the spacing, the higher the velocity. A longitudinal slot is provided along the top of the barrel to minimize the heating effect of eddy currents when a metal barrel is used. If the barrel is hard rubber or plastic, this slot is, of course, unnecessary.

In order to reduce the residual magnetism of the issuing particles a high frequency demagnetizing coil is located near the muzzle. This coil has a separate source of excitation from the exciting coils.

When direct current is used, it is broken up into impulses by means of a breaker or commutator and excites the coils in the same manner as when alternating current is used.

Speed Changer Has Low Losses

OPERATING on the principle of a vernier, the magnetic speed changer illustrated is capable of providing either increased or decreased speed from an electric motor drive. Assigned to the O. S. Walker Co., the patented speed control is adaptable to being built integrally with the motor housing.

The motor shaft is a hollow torque tube which carries, keyed to its right end, an intermediate rotor made of magnetic material such as iron. Held to this rotor by means of a series of screws is a laminated magnetic cylinder having pole teeth formed axially on its outer surface. These screws, as well as a separator ring between the laminated section and the intermediate rotor proper are of a nonmag-

The Direct Way

AN ALL-ELECTRIC ADJUSTABLE-SPEED DRIVE FOR A-C CIRCUITS

RELIANCE V★S DRIVE

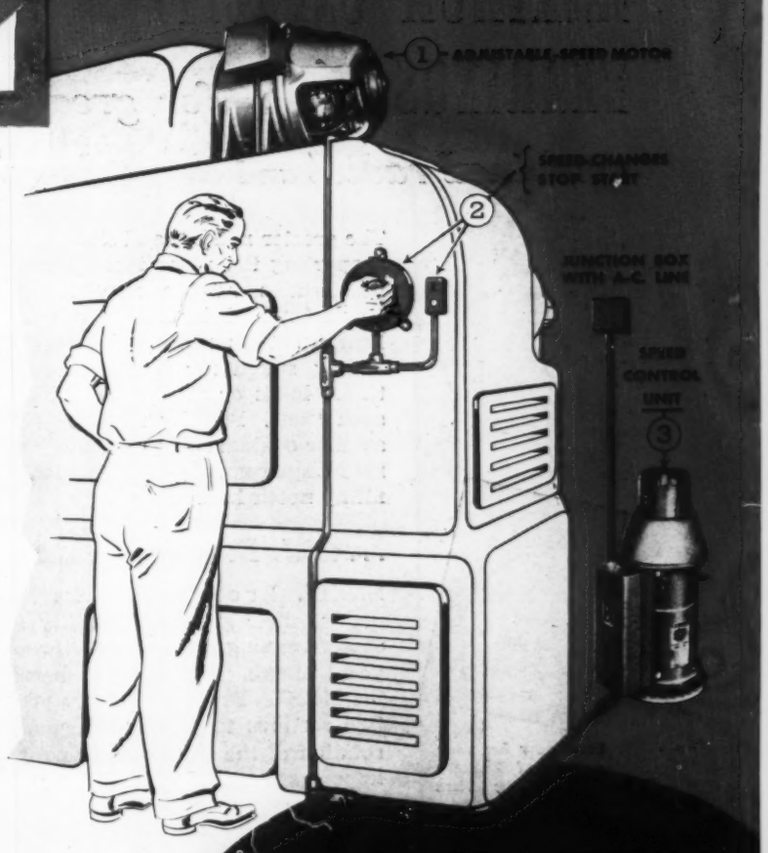
Speed Ranges up to 16 to 1 — Sizes 1 to 30 hp.

THE V★S way shortens the distance from power to work. It's the direct way, eliminating intermediate speed-changing devices, clutches, gear trains, a multiplicity of handles and knobs. It makes full use of the electric motor as a simple speed-changing device as well as a power unit (1).

From one handle in a convenient spot speeds are changed smoothly over ranges up to 16 to 1 while the machine is running. To stop, press a button; to start again, press another and the machine comes back to its previous speed (2).

And here are more features that help step up production: quick stopping, reversing, safe speeds for threading and inching, ample starting torque with smooth acceleration.

Using a proven principle of speed control, the Reliance V★S Drive now gives you these many advantages at a new low price. This is possible because of the packaged speed control unit (3) which is connected by three wires to a 3-phase a-c. power circuit. It takes little space and can be mounted anywhere.



RELIANCE ELECTRIC & ENGINEERING COMPANY

1079 Ivanhoe Road • • • Cleveland, Ohio

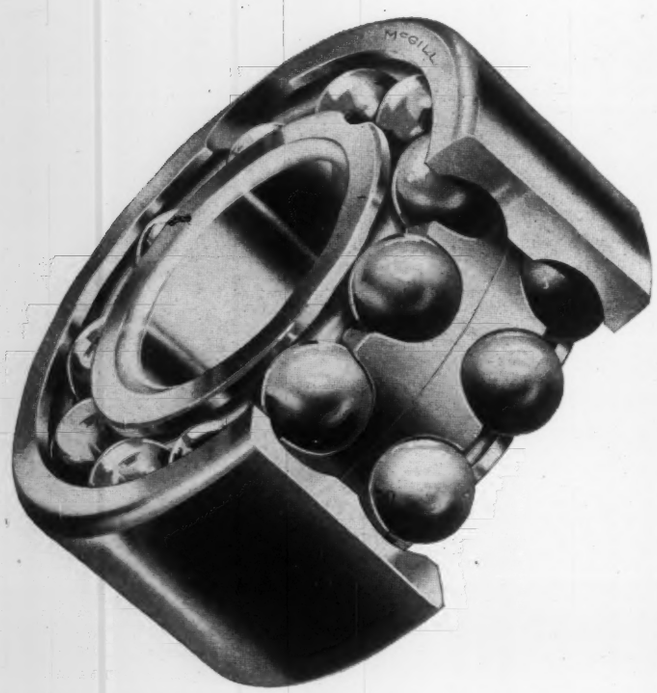
BIRMINGHAM • BOSTON • BUFFALO • CHICAGO • CINCINNATI • DETROIT • GREENVILLE (S. C.)
HOUSTON (TEX.) • LOS ANGELES • NEW YORK • PHILADELPHIA • PITTSBURGH • PORTLAND (ORE.)
ST. LOUIS • SAN FRANCISCO • SYRACUSE (N. Y.) • AND OTHER PRINCIPAL CITIES.

CONVENIENCE, WITHOUT LIMITATIONS

The start-stop button and speed changer can be placed anywhere that you can run a wire. Grouped with other control elements for the machine they make centralized control complete.

Get Bulletin 309 for details.

RELIANCE A-C D-C MOTORS



McGILL . . . MAXIMUM CAPACITY BEARINGS . . . *for greater combined radial and thrust loads*

The greater number and size of balls supporting the races increases load possibilities in the new McGILL Maximum Capacity Double Row Ball Bearing. This new construction is ideally suited for heavy radial or thrust loads or any combination of such loads. Rigidity resulting from angular contact fit-up does not allow race displacement — thus preventing filling notch interference.

Send now for your copy of Bulletin describing this bearing.

. . . with Bronze Retainers

McGILL Bronze Retainers have proven their greater durability and cooler-running qualities through years of use. In this NEW bearing the McGILL Bronze Retainers are in two sections to permit independent rotation of the two rows of balls — important under severe operating conditions.

BEARING DIVISION

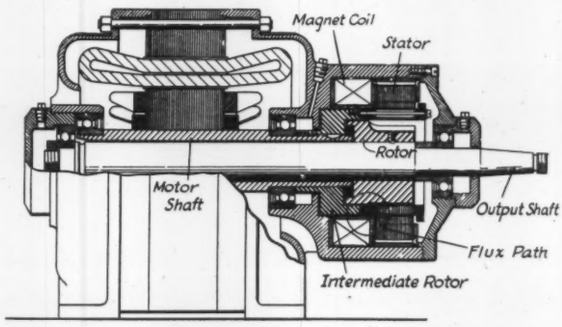
McGILL MANUFACTURING CO.
1450 N. Lafayette Street
VALPARAISO, INDIANA

netic material such as stainless steel or bronze.

These design considerations contribute to an unusually compact assembly. The hollow cylindrical intermediate rotor which is driven by the torque tube motor shaft rotates between the stator and the rotor of the speed changer. Use of nonmagnetic materials for the spacers and screws serves to isolate the field and concentrate it across the rotor air gap.

Soft iron is used for the rotor which is fastened to the output shaft by means of a set screw. Shown in section this rotor is formed with three poles which have minimum clearance with both the laminated and solid portions of the intermediate rotor.

Magnetic laminations and the magnet coil form the stator. The interior surface of the laminated



Nonmagnetic materials isolate field and provide low losses in this motor speed changer

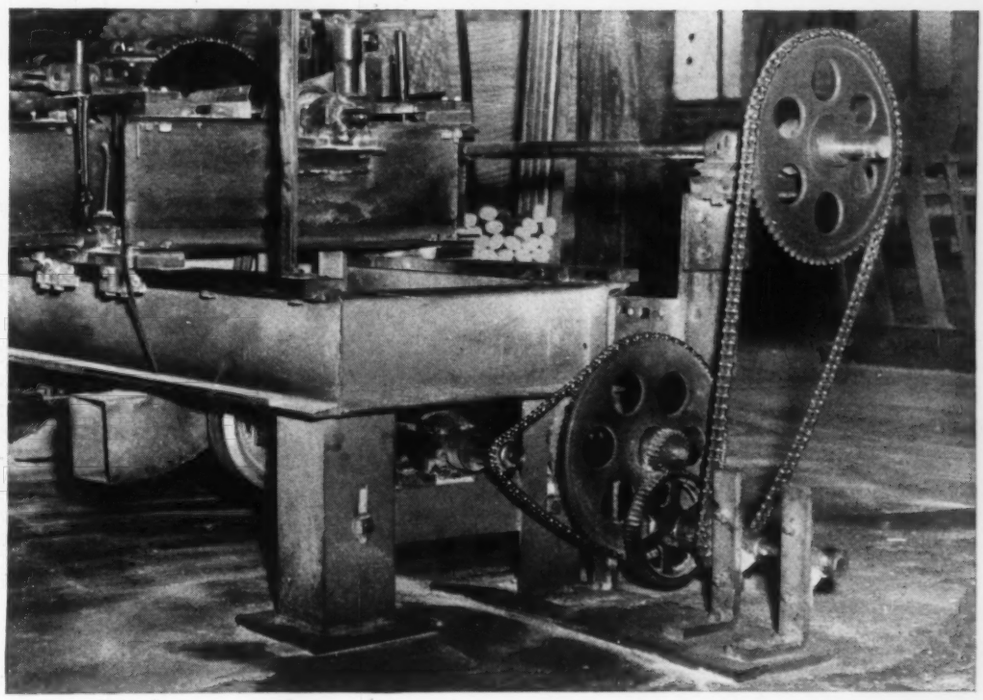
stator cylinder has axially formed teeth which are three fewer in number than those of the intermediate rotor. The arrangement of these several parts of the speed changer results in a flux path as indicated by the circle in the illustration.

Vernier effect of the rotating field is realized by the difference in the number of teeth in the motor driven rotor and the stator. The difference of three in the number of teeth corresponds to the number of poles on the rotor thus providing a field which constantly leads the rotor.

Whereas at moderate speeds the hysteresis loss in the rotor predominates, at high speeds the eddy current loss is greater. In order to minimize this loss the three pole faces of the rotor are electrolytically coated with copper or other low resistance material so that while induced eddy currents may be high, I^2R losses are held to a minimum.

Welding fittings of wrought carbon steel and carbon molybdenum steel made by either the open hearth or electric furnace methods are covered by a recent tentative standard of the American Society for Testing Materials. Fittings intended for use at temperatures in excess of 750 degrees Fahr. should be silicon killed. Carbon steel fittings upon which the final forming operation is completed at a temperature above 1150 degrees Fahr. need not be heat treated if cooled in still air. However, if the temperature exceeds 1650 degrees Fahr., the part must be normalized.

Requirements:—Large Reduction—No Slipping



● One of six machines in woodworking plant on which drives were changed to Diamond Roller Chains three years ago. They are started and stopped 25 to 30 times daily. This drive arrangement secured the low speed required at $140.00 less than a speed reducer, and is free of previous slippage troubles.

Solving the Drive Problem with DIAMOND Roller Chains

● Slippage on six woodworking machines caused frequent delays and adjustments, and interfered with production. A study of the requirements—large reduction—no slipping—and frequent starting and stopping—resulted in the selection of DIAMOND Roller Chain Drives,—one from the 1200 r.p.m. motor, reducing to 200 r.p.m., and a second drive reducing the speed to 18 r.p.m. . . . This arrangement cost $140.00 less than a speed reducer for the same work.

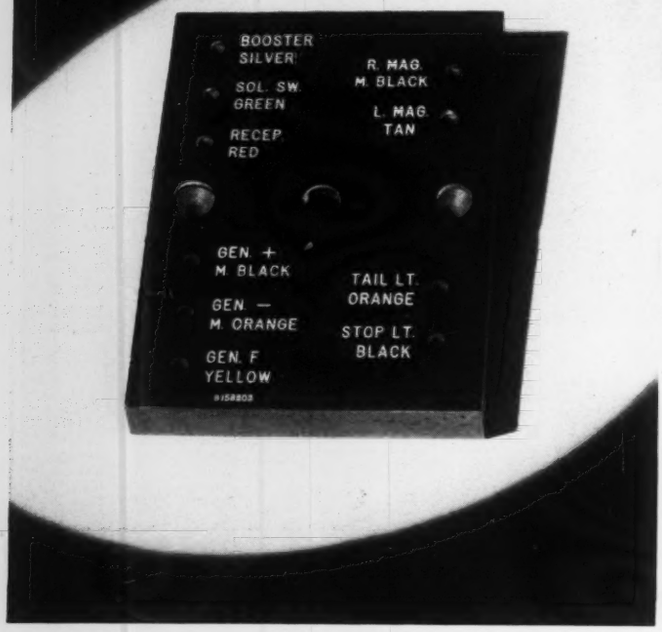
Three years of operation with no replacements have proven the economy and reliability of these drives, and since they do not slip or creep, the exact speed desired is obtained at all times. Productive output is kept uniformly high, and delays and adjustments are eliminated.

For very slow speeds of a few r.p.m.s or speeds up to 4000,—for fractional hp. capacity or a thousand—positive DIAMOND Roller Chain Drives of single and multiple widths give you practically 100 per cent power transmission efficiency—at low initial and maintenance costs.

If you want to improve your motor or machinery drives, let us make recommendations—or write for our helpful Catalog 517. DIAMOND CHAIN & MFG. CO., 435 Kentucky Ave., Indianapolis, Ind. Offices and Distributors in All Principal Cities.

DIAMOND ROLLER CHAINS

INSULATION



One of the bright spots in modern high speed production is the increasing use of G-E laminated Textolite for insulation and structural support in a great variety of industrial applications.

In some industries, for instance, one use of the material is for terminal boards where its insulating properties are supplemented by its durability, easy machinability, light weight, corrosion resistance and good printing surface.

It is difficult, as a matter of fact, to conceive of a non-plastic material meeting all these requirements. But G-E laminated Textolite is an unusual material manufactured under rigid control and fabricated to specification.

• • •

For a copy of our new booklet "One Plastics Avenue," write Plastics Department, General Electric Co., One Plastics Avenue, Pittsfield, Mass. Sales offices in New York, Chicago, Cleveland, Fort Wayne, Meriden, Philadelphia, Lynn, Rochester and Detroit.

PD-153

PLASTICS DEPARTMENT
GENERAL ELECTRIC

ASSETS to a BOOKCASE

Flash!

By Harold E. Edgerton and James R. Killian Jr.; published by Hale, Cushman & Flint, Boston, 203 pages, 8½ by 11 inches, cloth bound; available through MACHINE DESIGN *for $3 postpaid.*

High speed photography, particularly the stroboscopic or single-flash type, is becoming an increasingly useful tool in design departments. Machine motions which formerly had to be assumed may now be seen clearly and ways of dealing with them in design are consequently improving.

Prof. Edgerton's work with the stroboscope he invented is well-known to engineers but this book will serve to dramatize it. The subjects of the pictures shown are not all mechanical; indeed, the reverse is true. These subjects were chosen because of the relative ease with which they could be photographed, but imagination can substitute a mechanical motion for those illustrated.

Representative shots pertinent to design include pictures of yarn spinning which clearly show effects of centrifugal force and windage; bending of airplane propellers; reactions on the surface of steel being quenched; and action of water about a ship propeller.

Directions for assembling a single-light flash unit for high speed photography are given, along with a wiring diagram and parts list.

A comprehensive bibliography of publications relating to high speed photography is appended and the emphasis of the articles mentioned is on mechanical subjects.

□ □ □

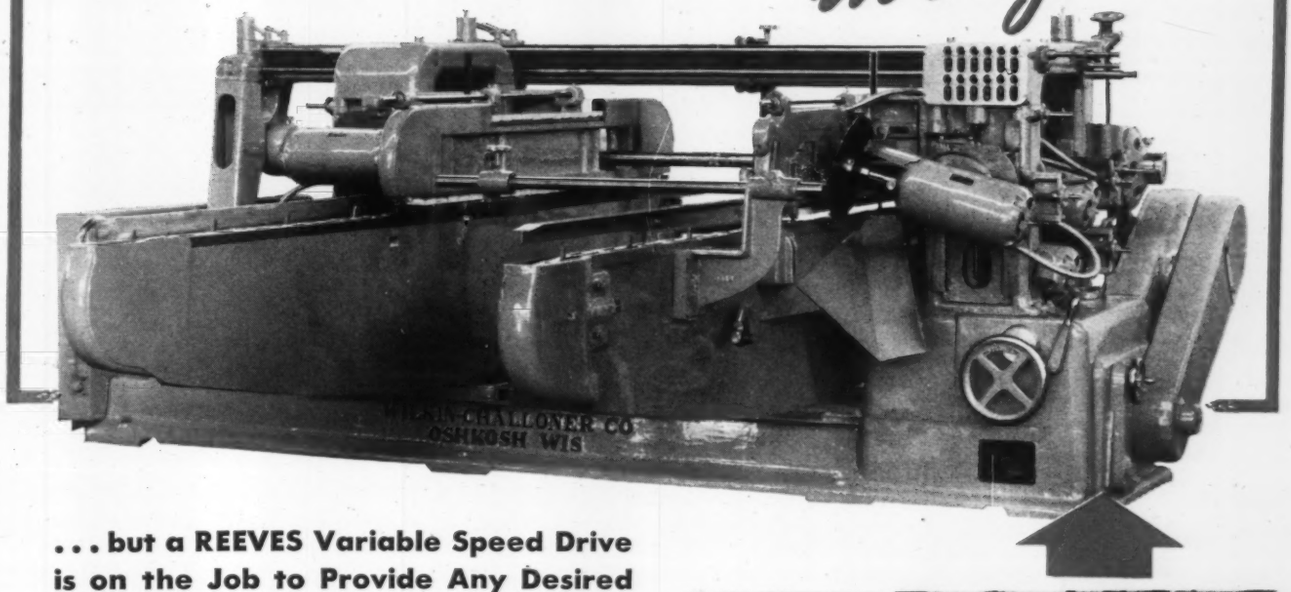
The Autobiography of an Engineer

By William LeRoy Emmet; published by the American Society of Mechanical Engineers, New York; 233 pages, 6 by 8¾ inches, cloth bound; available through MACHINE DESIGN *for $3.50 postpaid.*

In a sense this book, published first in 1931, is not only the history of an engineer but of an engineering era. Mr. Emmet's career has covered virtually all of the spectacular engineering developments of the last 60 years, during which the great technical advances we know have been made. He has played a leading part in at least four important phases of electrical development: Design of apparatus and methods of distribution of central-station electric power; steam-turbine electric apparatus; electrical propulsion of ships; invention of the mercury-vapor power system.

First edition was written before economic depression had made itself fully felt. Two chapters have now been added which relate more of Mr. Emmet's struggles in the interim to attain commercial success for his mercury-vapor process. He also has elaborated on certain socio-economic beliefs as they have been

NO SPEED CONTROL *in Sight*

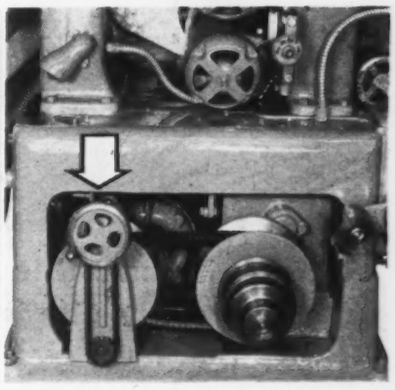


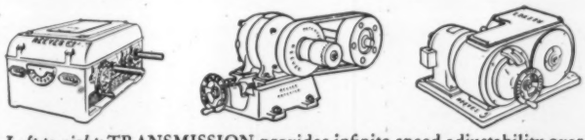
. . . but a REEVES Variable Speed Drive is on the Job to Provide Any Desired Speed Merely by Turning a Handwheel

In industry after industry, machine after machine has been made more flexible and adaptable to different sizes and classes of work—given new speed and accuracy—through the application of REEVES Variable Speed drives. Many of these installations consist of REEVES *Internal Operating Parts* which are completely enclosed within the framework of the machine itself—as in the Double End Tenoner, pictured above. . . . Replacing the four-speed motor previously used for governing the rate of feed of stock through the Tenoner, the REEVES Motodrive provides far greater smoothness of operation as a result of infinitely variable speed regulation. . . . A similar installation on the machines you build may be equally effective. Write for copy of Catalog-Manual G-397. No obligation.

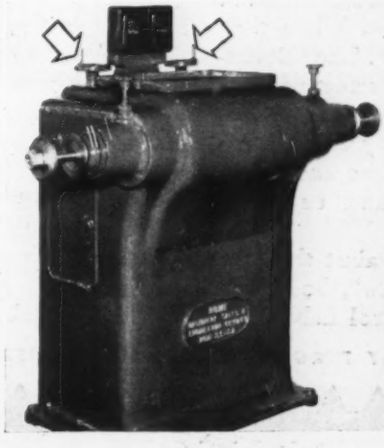
REEVES PULLEY CO. • Dept. H • COLUMBUS, INDIANA

End view of Wilkin-Challoner Double End Tenoner shown above. End cover has been removed to show installation of REEVES Motodrive Internal Operating Parts in space formerly occupied by four-speed motor.





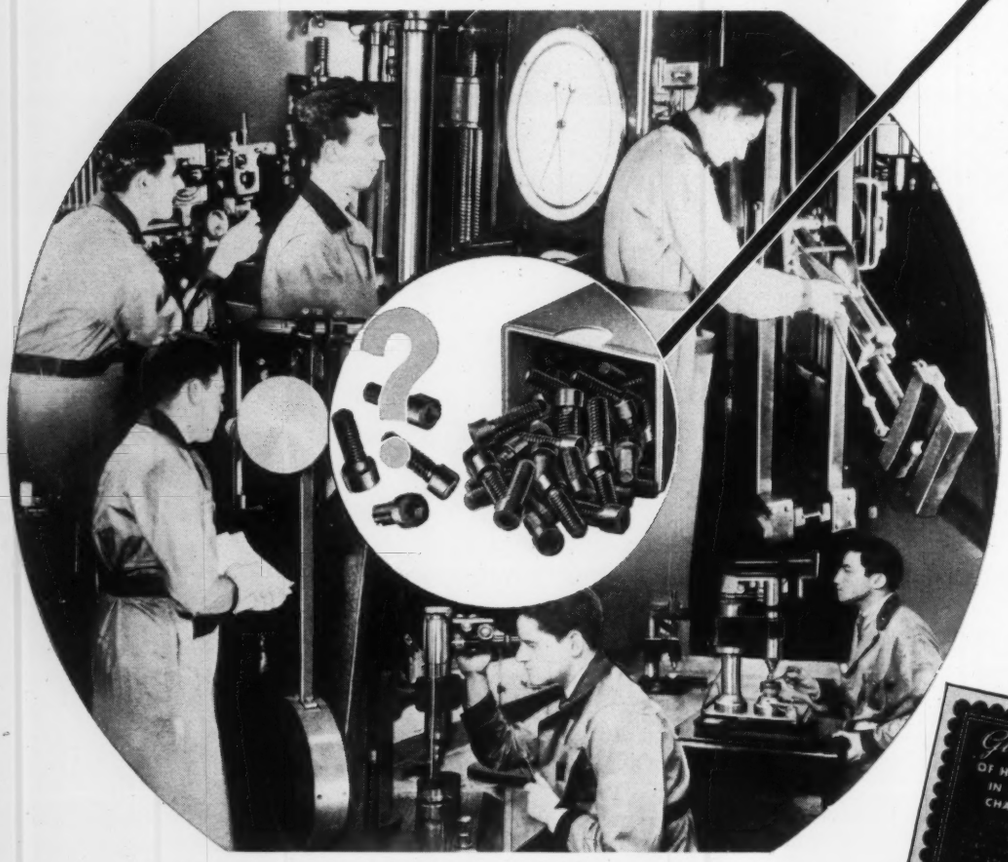
Left to right: TRANSMISSION provides infinite speed adjustability over wide range, 2:1 to 16:1 inclusive; modern, compact, open and enclosed designs in sizes up to 78 H.P. . . . VARI-SPEED Motor Pulley, simple, direct drive for requirements from fractional to 15 H.P. 3:1 range. MOTODRIVE combines motor, speed varying mechanism and reduction gears; sizes to 10 H.P.; ratios of speed variation, 2:1 through 6:1.



Another example of REEVES adaptability. Two sets of Motodrive internal operating parts used to provide infinitely variable speeds for the two independent spindles on a Rome Polishing and Buffing Lathe. Arrows point to REEVES Handwheels.

REEVES *Accurate Positive* SPEED CONTROL

WE'LL KEEP THE "*Doubtful Few*" OFF YOUR ASSEMBLY BILLS



Parker-Kalon's Unequalled Quality-Control Laboratory eliminates the extra costs built up by "doubtful" screws

Fastening devices cost little . . . when they work right. When they don't, they cost plenty! The "Doubtful Few" . . . the imperfect units in a lot that won't drive properly, or fail in service . . . carry with them a high bill for extra time and labor, interrupted work and customer dissatisfaction.

To protect you against the cost-boosting "Doubtful Few", the Parker-Kalon Quality-Control Laboratory was established. Without counterpart in the industry, it makes it possible to hold Parker-Kalon Hardened Self-tapping Screws, Socket Screws and other fastening devices to higher standards than ever before could be attained!

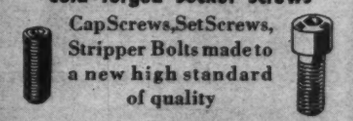
Specify PARKER-KALON for fastening devices that ALWAYS WORK RIGHT AND HOLD TIGHT. Send for folder and free samples. Parker-Kalon Corp., 192-200 Varick Street, New York.

SOLD ONLY THROUGH RECOGNIZED DISTRIBUTORS

COSTS NO MORE *to get this Parker-Kalon Quality-Control Guarantee with every box of . . . .*

Hardened Self-tapping Screws
Types, sizes, head-styles for every assembly of metal or plastics

Cold-forged Socket Screws
Cap Screws, Set Screws, Stripper Bolts made to a new high standard of quality



Wing Nuts-Cap Nuts-Thumb Screws
Cold-forged . . Neater, Stronger

Quality-Controlled **PARKER-KALON Fastening Devices**

stimulated by the nation's political experiences of the last decade.

Perhaps the most startling and significant fact revealed by the book is Mr. Emmet's bold imagination, his will power and daring courage. Outstanding men probably have always had these qualities but nowhere was a tone of optimism so notable as among the industrial and engineering pioneers who developed the industrial United States of the last 50 years.

□ □ □

Mastering Momentum

By Lewis K. Sillcox; published by Simmons-Boardman Publishing Corp., New York; 264 pages, 6 by 9 inches, cloth bound; available through MACHINE DESIGN *for $2.50 postpaid.*

The momentum the author treats is that of railway equipment, hence to a certain extent this volume has rather limited and specialized interest. Purpose of the writer is to show the influence of modern transport trends on the design of railway equipment. On the other hand, much of the subject matter applies to all types of nonstationary machines, thus giving the book wider appeal.

A great deal of space is devoted to failures of bearings and springs and a discussion is included of photoelastic analysis in connection with axles. The appendix gives additional pertinent information.

□ □ □

Working Stresses

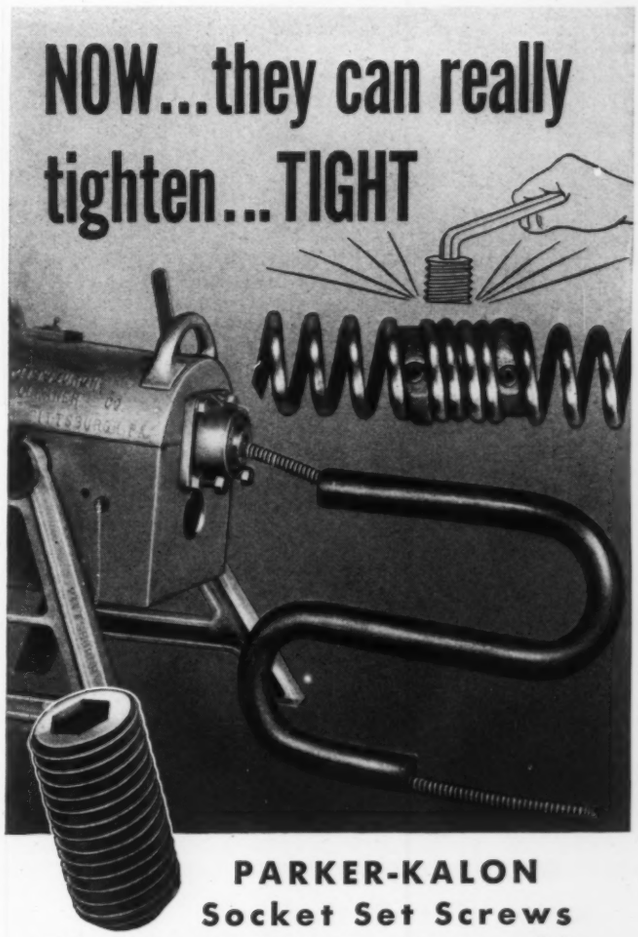
By Joseph Marin; published by Rutgers University Press, New Brunswick, N. J.; 41 pages, 5½ by 8½ inches, cloth bound; available through MACHINE DESIGN *for $1 postpaid.*

Combined states of stress leading to failure of materials subjected to static, fatigue and creep loadings are mainly discussed in this little volume.

Although the text matter is brief, it is augmented in effect by the direct references to the articles in the bibliography. In other words, the author summarizes in a sentence or two the work explained in detail in the reference, leaving the reader the opportunity of investigating further.

A number of useful graphs are appended and the bibliography contains many authoritative works.

Veritable leviathan, this truck weighs 30 tons and packs a payload of 50 tons. Considering its size, this huge Mack truck is exceptionally maneuverable and highly efficient. To keep pace with trucks of this size, an electric shovel with a six-ton bucket is employed to load a truck in less than three minutes.



PARKER-KALON
Socket Set Screws
End "Doubtful" Screw Trouble

A great tool – this Pittsburgh Pipe Cleaner! And one of the features which makes it so is a special two-piece coupling for joining numerous lengths of cable. When the cable drives into a pipe line clogged with rock-hard deposits, the connections are subject to terrific strains. So the Socket Set Screws that hold the halves of this coupling together must be set up unusually tight.

Too many sockets cracked and split under the heavy wrench pressure even though "good" screws were used. Then The Pittsburgh Pipe Cleaner Co., of Pittsburgh, Pa., decided to find out if Parker-Kalon QUALITY-CONTROL was more than a talking point . . . if it would really eliminate the "doubtful" screws causing all the trouble. A trial soon made it clear that "doubtful" screws – screws that look all right but fail to work satisfactorily – just don't get past Parker-Kalon's 16-point inspection routine.

Why take chances with "doubtful" screws – specify Parker-Kalon. Get free samples – try them! Parker-Kalon Corporation, 192-200 Varick Street, New York.

Quality-Controlled

16-point test and inspection routine covers: Chemical Analysis; Tensile and Torsional Strength; Ductility; Shock Resistance under Tension and Shear; Hardness; Head diameter, height and concentricity; Socket shape, size, depth and centricality; Class 3 Fit Threads; Clean-starting Threads.

PARKER-KALON
COLD-FORGED
Socket Screws

Specify

"IRVINGTON" VARNISHED CAMBRIC AND TAPE

● "IRVINGTON", pioneer in the commercial development of varnished insulations, was the first to produce seamless bias varnished cambric and tape, the first to perfect the manufacture of black varnished cambric.

Constant research and development have produced in "IRVINGTON" Varnished Cambric and Tape a balance of mechanical and electrical properties that is unsurpassed for commercial insulation applications. These insulations generously comply with appropriate N.E.M.A. and A.S.T.M. specifications. Samples for your own test will be forwarded upon request.

"IRVINGTON" varnished insulations due to their pliability and smoothness of finish are adapted to every requirement of hand or machine application and "IRVINGTON" production facilities have been expanded to a point that insures continuity of supply.

Write for full technical data now.

"IRVINGTON" BLACK STRAIGHT CUT VARNISHED CAMBRIC AND TAPE have outstanding aging and insulating properties, high resistance to moisture and lubricating oil.

"IRVINGTON" BLACK SEAMLESS BIAS VARNISHED CAMBRIC AND TAPE are similar in general characteristics to Black Straight Cut Cambric but are ideal for covering curved and irregular surfaces, maintaining good dielectric strength after stretching.

"IRVINGTON" YELLOW STRAIGHT CUT VARNISHED CAMBRIC AND TAPE have superior resistance to transformer and lubricating oil, good aging and insulating qualities, and resistance to moisture.

"IRVINGTON" YELLOW SEAMLESS BIAS CAMBRIC AND TAPE have properties similar to Yellow Straight Cut Cambric and are recommended for use on curved and irregular surfaces, maintaining good dielectric strength after stretching.

"IRVINGTON" VARNISHED CAMBRIC CABLE-CLOTH is manufactured to meet a variety of differing specifications.

IRVINGTON INSULATION

IRVINGTON VARNISH & INSULATOR CO.

IRVINGTON, NEW JERSEY, U. S. A.

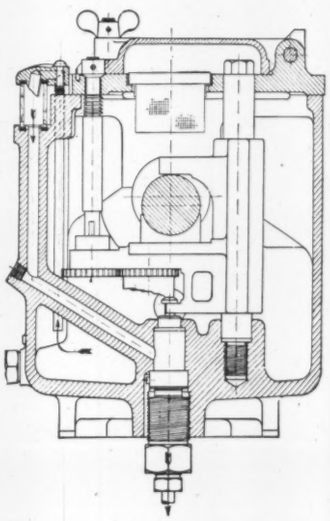
PLANTS AT IRVINGTON, N. J. and HAMILTON, CANADA

Representatives in 20 Principal Cities

New PARTS AND MATERIALS

Lubricator Has Four Pumping Units

MECHANICAL lubricator, type HD, is announced by the Nathan Mfg. Co., 250 Park avenue, New York. Four independent pumping units, one for each feed outlet, are located inside the oil reservoir, and each consists of a packless piston fitted tightly into a cylinder. These units draw oil from the reservoir through sight-feed glasses in drops by a vacuum created during the suction stroke. Each unit is actuated by a yoke which in turn



Four independent pumping units consisting of tightly fitting packless pistons and cylinders are located inside oil reservoir of mechanical lubricator

receives its movement from an eccentric shaft. The lubricator can be provided with either a ratchet drive for reciprocating movement, or with a rotary drive. It is furnished with from one to four feeds, each guaranteed to operate against a pressure of 20,000 pounds per square inch. The oil in each pumping unit can be regulated independently of that in other units, by adjusting the effective stroke of the pumping pistons. The lubricator is particularly adapted to applications in multi-stage air compressors, high pressure gas pumps, and in many types of processing machines.

Sheet Packing Resists Oil

TWO types of sheet packing, one made of Ameripol and the other of Koroseal, are announced by the B. F. Goodrich Co., Akron, O. The Ameripol packing is a dark material superior to natural rubber and other packings in its resistance to oil. It ages well and provides excellent resistance to heat and cold as well as water absorption. Its tensile strength is approximately 1500 pounds per square inch, elongation in 2 inches is 400 per cent, Shore durometer hardness 79 to 82. Made to order in 100-pound rolls only, it is approximately 36 inches wide in thicknesses from $\frac{1}{32}$ to $\frac{1}{4}$-inch inclusive. The Koroseal packing resists action of oils, solvents and some corrosives. Tensile strength is about

Most Satisfactory!

Stands up Better!

Much Superior!

Very Efficient!

. . . SUCH ARE THE VERDICTS OF WRINKLE USERS

It is on this basis . . . the universal acceptance of prominent product finishers . . . that we urge you to plan your product finishing requirements around WRINKLE . . . the one coat finish. Its economy of application . . . its durability . . . the eye appeal with which it endows both low priced and high quality articles . . . are WRINKLE advantages you cannot afford to ignore. There is a WRINKLE licensee near you, waiting to help you. Let us send you his name. » »

EFFICIENCY EQUIPMENT COMPANY, Inc.

AN EFFICIENT LINE OF EQUIPMENT FOR THE OFFICE . . . . .

360 WEST SUPERIOR ST.

SUPerior 8623 CHICAGO, ILL.

New Wrinkle, Inc.
Mutual Home Building
Dayton, Ohio

Gentlemen:

Practically all of the files that we sell are finished in wrinkle finish and we believe that there is no comparison between the wrinkle finish and the smooth finish. The wrinkle finish not only stands up better but has a much better appearance and it balances with most any other type of finish much more readily than the smooth finish.

Of course, from a manufacturer's standpoint, the wrinkle finish also covers up a multitude of sins (scratches, spot welding marks, etc.).

Very truly yours,

Efficiency Equipment Co., Inc.

E. H. Johnson

j/lhz

Efficiency Electro and Secretarial File

BLACK & DECKER

BLACK & DECKER ELECTRIC CO.

FRACTIONAL HORSEPOWER ELECTRIC MOTORS

KENT, OHIO

R. J. LAMB PRESIDENT
M. H. SPIELMAN VICE PRES. AND GEN. MANAGER
W. H. POESSE VICE PRES. AND PLANT MANAGER
A. E. NASH SECY. TREAS

BRANCHES BOSTON, NEW YORK, PHILADELPHIA, ALLENTOWN, CLEVELAND, CHICAGO, CHARLOTTE, DETROIT, DALLAS, BUFFALO, MINNEAPOLIS, DALLAS, ST. LOUIS, MONTREAL, TORONTO, SYDNEY, AUSTRALIA

New Wrinkle, Inc.
Dayton, Ohio

Attention: Mr. R. F. Ohmer

Gentlemen:

In compliance with your request of October 30, we are pleased to enclose herewith a gloss photograph with descriptive article attached to the back of the picture.

We appreciate very much your interest in our behalf, and wish to take this opportunity to inform you that we have used wrinkle finish for a period of more than a year, and find it most satisfactory.

In the future if you will address the issue of "New Wrinkles in Finishing" to the undersigned, it will be greatly appreciated.

Yours very truly,

W. F. Fryburg

Black & Decker Motor for an Industrial Vacuum Cleaner

3727 N. PALMER STREET

TELEPHONE CONCORD

REX-O-graph INC.

Manufacturers of Duplicating Equipment

MILWAUKEE, WISCONSIN

New Wrinkle, Inc.
Mutual Home Building
Dayton, Ohio

Gentlemen:

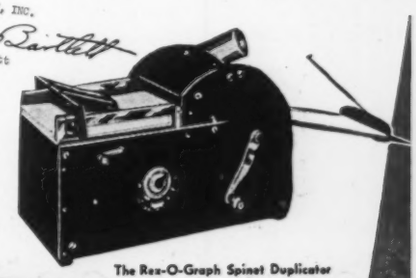
In reply to your request of May 2, we are enclosing a circular describing the Rex-O-Graph spirit duplicators. The complete Rex-O-Graph line, that is, both spirit type and gelatin type duplicators, are now finished in the black wrinkle finish. We have found this to be a very efficient and attractive method of painting our product. It has proven to be much superior to a solid color. Some advantages are that it is easy to handle in the factory, and if it does become scratched, the finish is easy to touch up and restore to original appearance. We do this by using a small brush and applying the paint, and then lightly touching it with the fingertips to simulate the original wrinkled appearance. We have also found that this wrinkled finish helps cover up defects in the metal, solder and weld marks, and also file marks.

Very truly yours,

REX-O-GRAPH, INC.

C. C. Bartlett

CCB:jdl
Enclosure

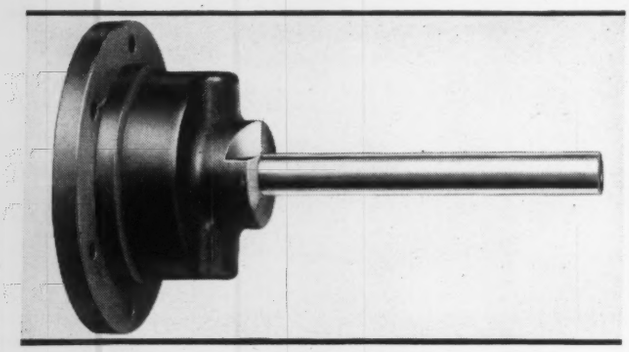


The Rex-O-Graph Spinet Duplicator

U. S. Patents • 1,689,892 • 1,732,661 • 1,831,323 • 1,878,316 • 1,883,408 • 1,896,594 • 1,936,913 • 1,950,417 • 1,969,164 • 1,976,191 • 1,980,309 • 1,991,527 • 1,991,528 • 2,037,331 • 2,069,252 • 2,077,112 • 2,124,703 • 2,154,954 • Des. 88,001 Other Patents Pending Canadian Patents • 311,503 • 311,504

NEW WRINKLE, INC.

DAYTON, OHIO



—Special Pumps for YOUR needs

. . . . for coolant—pressure—lubrication — hydraulic operation of machines — and miscellaneous combinations.

Tell us your pump needs —

Brown & Sharpe Mfg. Co.
Providence, R. I.
U. S. A.

BROWN & SHARPE PUMPS

SPIRAL GEARING

—in the finer pitches 14 to 96 D. P.

Also SPURS — BEVELS — WORM GEARING

Your small Gear needs may be few or many — experimental or production — 'fussy' or 'commercial' — intricate or simple — Whatever they are, consult SPECIALISTS such as—

Made to order only—No stock—No catalog

Gear Specialties

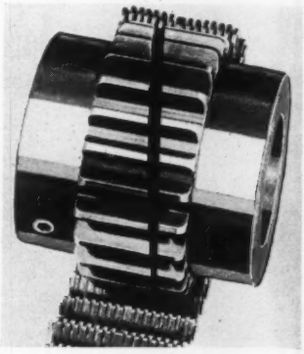
2670 W. MEDILL AVE. Phone Humboldt 3482

CHICAGO

2200 pounds per square inch, elongation 300 per cent, Shore durometer hardness 73 to 77. It is furnished in 26 by 26-inch sheets.

Coupling Pinions Faced Diagonally

INTENDED to counteract shearing of the pins in the chain, the Type D flexible chain coupling is announced by the Ramsey Chain Co. Inc., Albany, N. Y. Instead of having straight sides, the new pinions are faced diagonally on the adjoining sides. It is said that the full tensional strength of the chain's width

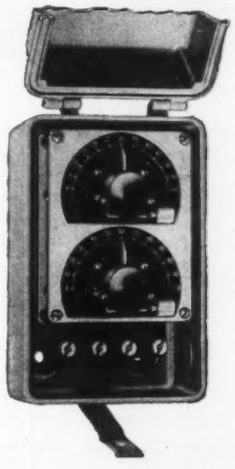


Pinions in flexible chain coupling are faced diagonally instead of having straight sides

is employed by the pinions as, through the chain, the one pinion drives the other. Wear of teeth because of excessive misalignment is claimed to be distributed evenly across the entire face of both pinions.

Combines Two Reset Timers

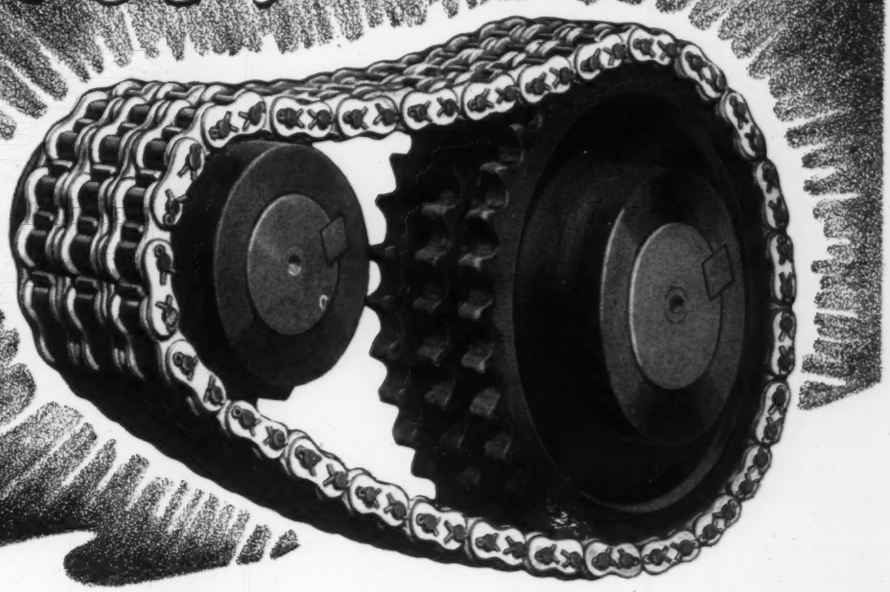
ESPECIALLY designed for applications requiring an adjustable and rapidly repeating time cycle, an automatic double reset timer is announced by the R. W. Cramer Co. Inc., Centerbrook, Conn. Consisting of two reset timer mechanisms mounted on a control panel and controlling common electrical circuits, the timers incorporate the latest improvements recently announced in Cramer time delay relays and reset timers. The furnishing of a 10-second impulse every 90 seconds for signalling or heating control purposes is a typical



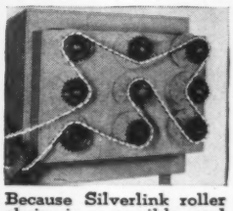
Automatic double reset timer is especially suited to applications requiring an adjustable and rapidly repeating time cycle

application, requiring a 120 and a 15-second timer. One timer is set to close the control circuit in 90 seconds, the other is set for 10 seconds. The switching arrangement of the entire instrument can be used as a single pole, double-throw switch. In operation, once the unit has been energized the first timer closes the circuit at

DON'T LET ITS BEAUTY FOOL YOU!



A type for every Transmission and Conveying need!

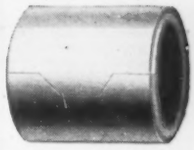


Because Silverlink roller chain is reversible and can be run on either side, it can be wound back and forth over a series of sprockets, where alternate directions of rotation are sought.

Silverlink Conveyor Chains in all standard pitches, ⅜" to 3", are available with many styles of attachment links for supporting, pushing, and moving a great variety of articles.

THIS CHAIN HAS ITS OWN SHOCK-ABSORBING ROLLER .. assures longer life on any application!

If you are looking for roller chain that can really "take it"—you've found it. Silverlink Roller Chain has the sparkling beauty that means extra sales appeal on any product, because it is quality-built in every detail. Precision design, high strength, great flexibility, quiet smoothness—every feature that makes for top performance and long life are in this chain. Write for Engineering Data Book No. MD-1757 today!



This unique, curled roller has a springy resilience which "absorbs" the stresses and hard blows of severe service.

LINK-BELT COMPANY

Ewart Plant, 220 S. Belmont Ave., Indianapolis

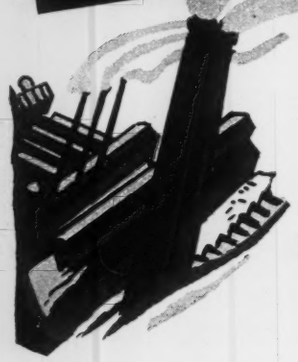
Chicago, Philadelphia, Atlanta, Dallas, San Francisco, Toronto

Branch offices, warehouses and distributors in principal cities

8391-B

LINK-BELT Silverlink ROLLER CHAIN

if it's speed control
IT'S A JOB
FOR LEWELLEN

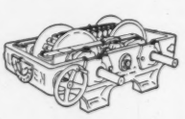


An
IMPORTANT WAY
to conquer today's
production challenge

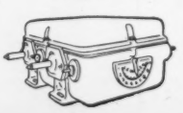
Provide the RIGHT SPEED
at the RIGHT TIME
for all production machines

Watch production INCREASE when a Lewellen Variable Speed Transmission is in the drive of each production machine! Costs are lowered—rejections reduced to a minimum—finished units improved in quality. Your operator has any speed at his command—even to a fraction of an r.p.m.—and that speed is accurately maintained until changed. Investigate the modern Lewellen way NOW! No obligation. Lewellen Manufacturing Co., Columbus, Indiana.

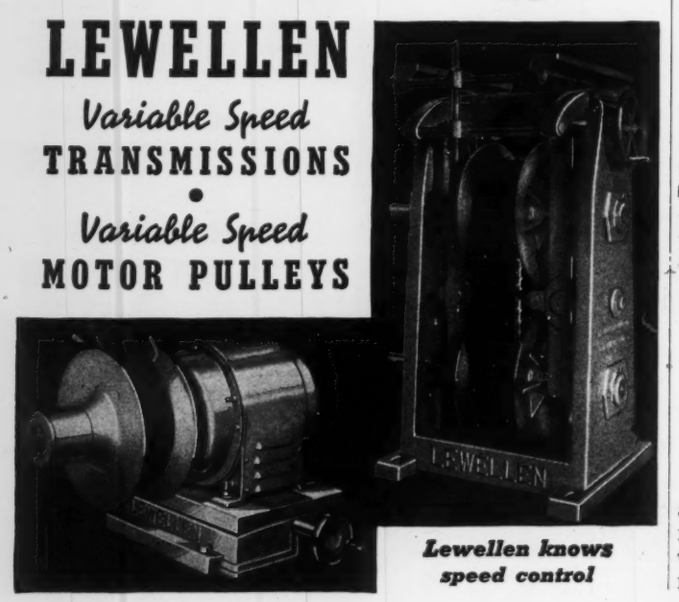
A Veneer Mill reports a production increase of 77% since the installation of a Lewellen Transmission and Automatic Controls.



Representing a small fraction of the cost of a group of machines it controls, a Lewellen Transmission maintains a uniform weight of upholstering padding for an automobile manufacturer. Production is greatly increased.



LEWELLEN
Variable Speed
TRANSMISSIONS
•
Variable Speed
MOTOR PULLEYS

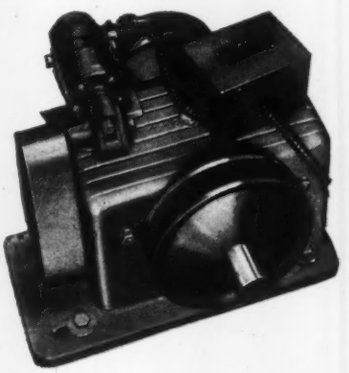


Lewellen knows speed control

90 seconds and the second then operates simultaneously with delivery of the desired impulse for 10 seconds.

Transmission Remote Controlled

A SERIES of Select-O-Speed transmissions equipped with electric motorized control is announced by the Ideal Commutator Dresser Co., 1059 Park avenue, Sycamore, Ill. These models supplement the standard line from fractional to 7½-horsepower capacity that are equipped with lever type and handwheel control. A two-button switch controls the speed. Changes in speed adjustments are easily made simply by pushing



Standard line of lever and handwheel-controlled transmissions is supplemented by electrically-controlled model

and holding either the fast or slow button until the desired speed is obtained. The electric control is especially recommended for remote control on processing machinery. A limit switch automatically stops the speed control motor at either the extreme maximum or minimum position, preventing stalling of the motor. Releasing the button stops the control motor and the transmission remains firmly locked in position. Changes in speed may be made in infinitely small increments throughout the complete range.

Rheostat Transfers Minimum Heat

SMOOTH, close control is assured with the F-500 rheostat announced by Hardwick-Hindle Inc., Newark, N. J. Each turn of wire is a separate resistance step. Contact system is completely enclosed. Ample

Ample air space between winding form and base insures minimum heat transfer from rheostat to mounting

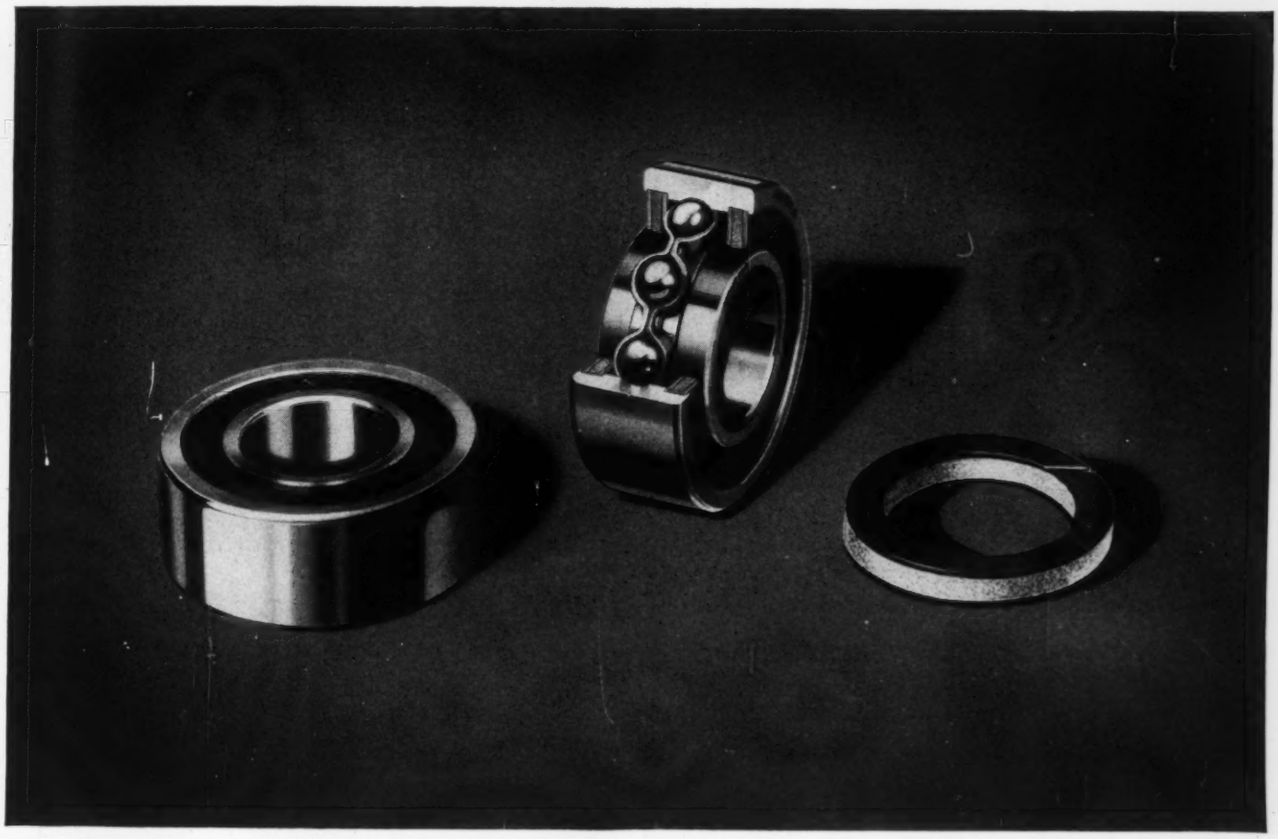
air space between the winding form and base insures minimum heat transfer to the mounting surface. All wiping contacts except that between the brush and the resistance element are eliminated, with one end of the

"NORMA-HOFFMANN"

Felt Seal Ball Bearings with

REMOVABLE, REPLACEABLE SEALS

are not only **SMOOTH AND QUIET,** *but also* **EASY TO INSPECT AND REGREASE**



Rigidly fixed in the outer ring, the felt seals in NORMA-HOFFMANN PRECISION BEARINGS are nevertheless easily and quickly REMOVABLE AND REPLACEABLE at will, thus facilitating inspection, cleaning or regreasing.

Moreover, the seal is entirely within the confines of the bearing, and therefore not exposed to injury. The NORMA-HOFFMANN seal construction avoids race distortion, assuring dimensional accuracy and quiet running.

The effective labyrinth formed by the THICK, FULL-SIZE FELT SEALS and plates against the recessed inner ring, provides extra protection against escape of lubricant or ingress of dirt. Grease capacity is ample for long service.

Wide, solid inner and outer rings afford maximum contact on shaft and in housing—making housing inserts unnecessary and militating against slippage, looseness, and escape of lubricant past outer ring.

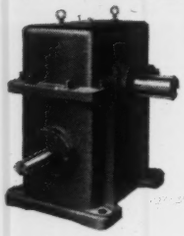
Write for the Catalog, describing the most complete line of self-sealed bearings in America, including several series with single felt seal, with single felt seal and side plate, and with double felt seal (illustrated above).

NORMA-HOFFMANN BEARINGS CORPN., STAMFORD, CONN. U.S.A.

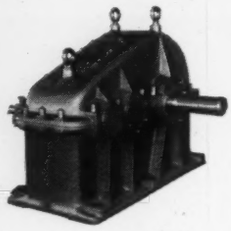
WE ARE READY TO SERVE YOU!

D.O.JAMES

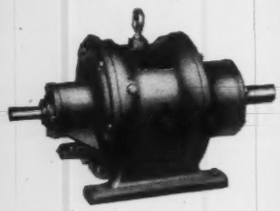
MAKERS OF ALL TYPES OF
SPEED REDUCERS AND CUT GEARS



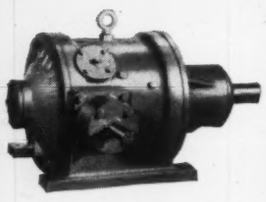
Heavy Duty
Worm Gear Reducer
Horizontal or Vertical Drive
Ratios 6 to 65:1 1/8 to 150 H. P.



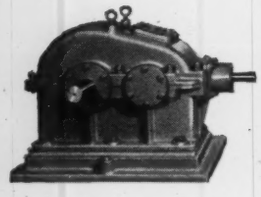
Continuous Tooth
Herringbone Reducer
Single, Double or Triple
Ratios 2 to 350:1 1 to 800 H. P.



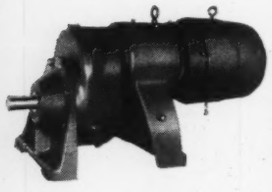
Planetary Gear Reducer
Horizontal or Vertical Drive
Ratios 4 to 1200:1 3/4 to 75 H. P.



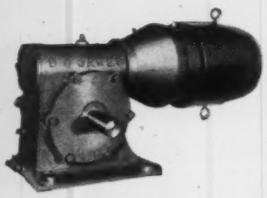
Right Angle Spiral Bevel
Planetary Reducer
Horizontal or Vertical Drive
Ratios 8 to 1200:1 3/4 to 50 H. P.



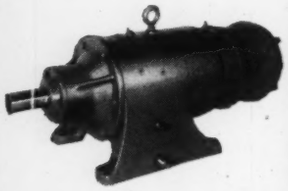
Right Angle Spiral Bevel
Herringbone Reducer
Ratios 6 to 45:1 2 to 250 H. P.



Motorized Speed Reducer
Horizontal or Vertical Drive
Ratios 1.2 to 9:1 3/4 to 50 H. P.



Motorized
Worm Gear Reducer
Horizontal or Vertical Drive
Ratios 6 to 65:1 1/8 to 50 H. P.



Motorized Speed Reducer
Horizontal or Vertical Drive
Ratios 4 to 1200:1 3/4 to 75 H. P.

CATALOGS ARE AVAILABLE COVERING
ALL TYPES OF SPEED REDUCERS

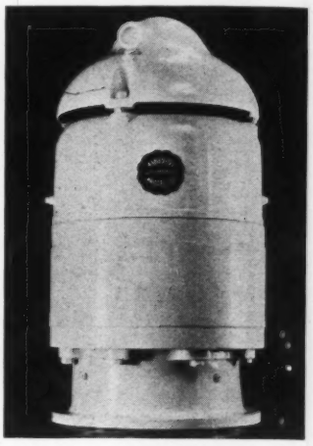
D. O. JAMES MANUFACTURING COMPANY
ESTABLISHED 1888
1120 WEST MONROE STREET • CHICAGO, ILLINOIS

FOR OVER 50 YEARS MAKING ALL TYPES OF GEARS AND GEAR REDUCERS

spiral connector integrally molded and the other end connected to the center terminal.

Vertical Motor Is Explosion Proof

SUITABLE for vertical applications in both Class I, Group D, and Class II, Group G locations, a vertical explosion-proof motor is announced by U. S. Electrical Motors Inc., Los Angeles. Hence the motor is designed for use where flammable substances are



Motor is designed for vertical use where flammable substances or combustible dust is encountered

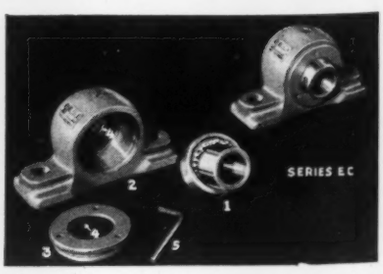
present and where combustible dust is encountered. The motor is fan cooled and has asbestos-protected windings. A variety of mounting flanges permits easy building into machines.

Thermostats Respond Quickly

MAXIMUM temperature range of the standard bimetal thermostats announced by Magnet Switch Co., 361 West Superior street, Chicago, is 250 degrees Fahr., although higher ranges are available on request. Differential is normally 3 degrees but can be reduced to 1 degree. Maximum load, depending on the model, ranges from 2 to 6 amperes, 115 volts alternating current. Because of its small mass and open construction, these thermostats have quick response to temperature changes, and accuracy can be kept within 1 degree plus or minus.

Seals Announced on Pillow Blocks

LABYRINTH seals of synthetic rubber are announced on the Series EC pillow blocks made by Ahlberg Bearing Co., 3053 West Forty-seventh street Chicago. Turning with the shaft and floating in the housing,

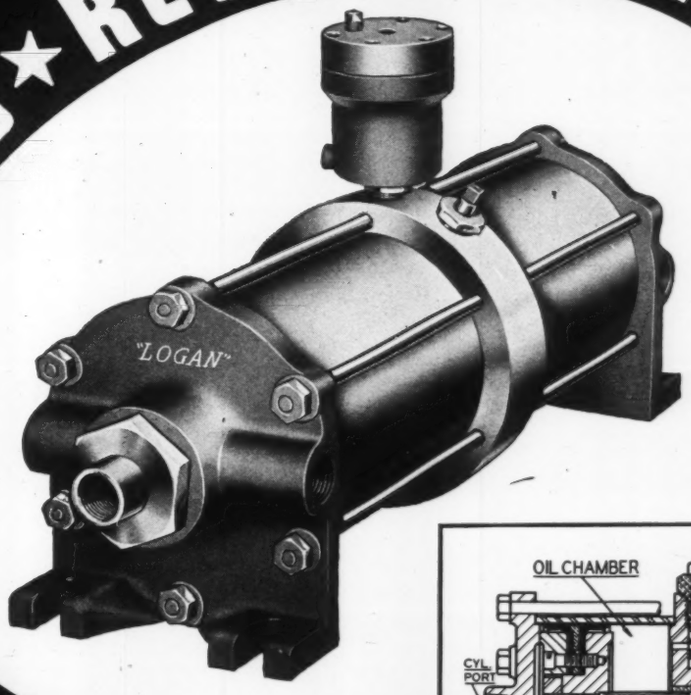


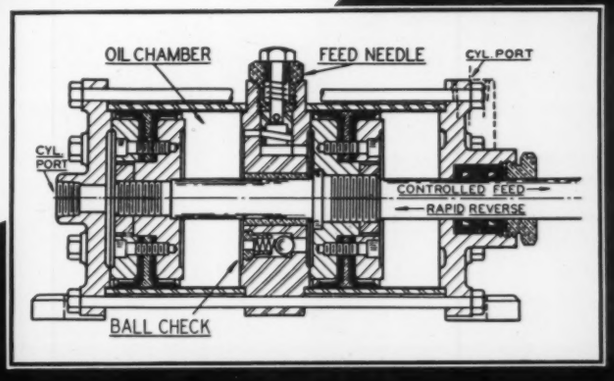
Turning with shaft and floating in housing, seals protect bearings in pillow blocks

these seals protect the bearings and retain lubricant. Complete unit consists of full self-aligning, precision ball bearings, mounted in one-piece rustproofed hous-

"LOGAN" AIR-DRAULIC CYLINDERS

★ NEW ★ REVOLUTIONARY ★





OPERATED BY AIR - YET ALL HYDRAULIC FEATURES RETAINED

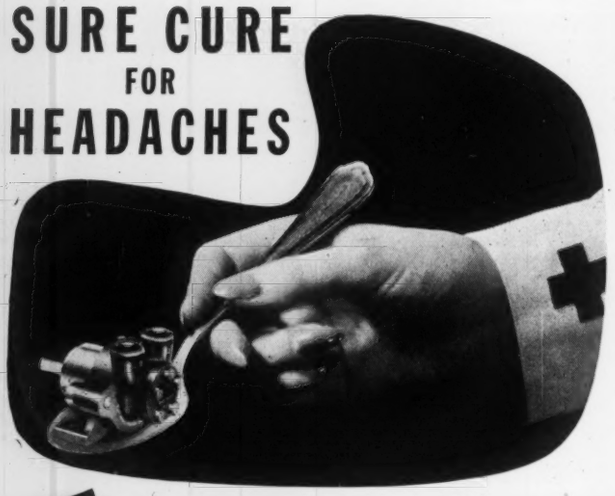
Industry has long needed a cylinder that combines the speed of an air cylinder with the smooth, steady cushioning action of a hydraulic cylinder. "LOGAN" Air-Draulic Cylinders retain all of the best features of both. They are adaptable wherever air pressure is available as a power means. The hydraulic regulating action is self-contained, providing a smooth flowing feed stroke, either continuous or adjustable. These new "LOGAN" Air-Draulic Cylinders are ideal for the operation of machine slides, drilling heads, work holding tables or machine operations requiring controlled movements. Write today for Bulletin 470 giving complete information.

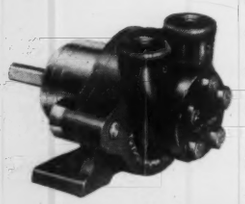
LOGANSPORT MACHINE, INCORPORATED

911 PAYSON ROAD, LOGANSPORT, INDIANA

Manufacturers of Air and Hydraulic Devices, Chucks, Cylinders, Valves, Presses and Accesssories

SURE CURE FOR HEADACHES



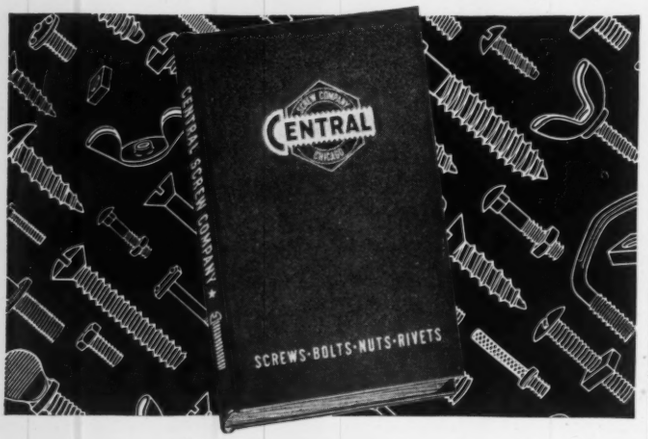


Here's one way to prevent pump service "headaches." Specify Tuthill Pumps for dependable, carefree performance. A type for every purpose, including Tuthill Stripped Pumps for direct incorporation into the design of your machine.

Write for Tuthill General Catalog today.

TUTHILL PUMP COMPANY
941 EAST 95TH STREET, CHICAGO, ILLINOIS

HOW THIS BOOK CAN HELP YOU



★ More than a catalog . . . this valuable reference book should be in the hands of every plant executive who specifies or purchases Screws—Bolts—Nuts—Rivets, either *standards from stock* or specials to order.

We say *more than a catalog*, because this book contains, in addition to complete technical and pricing data on standard Screws—Bolts—Nuts and Rivets, hundreds of true-to-product illustrations of special products. These "Special" Items tell at a glance, the scope of the "cold-upset" and "rolled-thread" process by which Central can produce parts to simplify your assembly operations. Learn what is available.

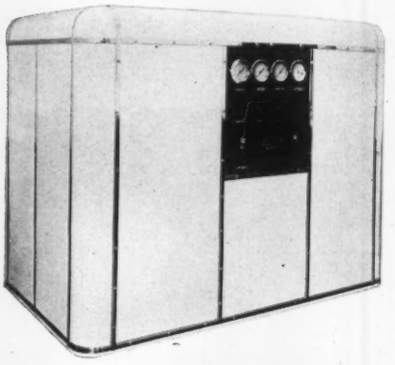
HOW TO GET IT FREE . . . ! It's easy . . . just write . . . your initials on your letterhead will do. No obligation. No cost. Your copy is waiting. Send for it today.

CENTRAL SCREW COMPANY
3509 SHIELDS AVENUE • CHICAGO, ILLINOIS

rings, accurately machined. The illustration shows (1) self-aligning ball bearings; (2) one-piece housing; (3) removable end cap; (4) labyrinth seals, and (5) mounting wrench.

Cabinet Panels Chromium Trimmed

FOR machines requiring a highly attractive housing, Lindsay Structure cabinets finished in white enamel with a chromium trim are announced by the Dry-Zero Corp., 222 North Bank drive, Chicago. These units, like other Lindsay Structure cabinets, are assembled under a principle which utilizes the high



All-steel housing utilizing new panel binding principle has finish of white enamel with chromium trim

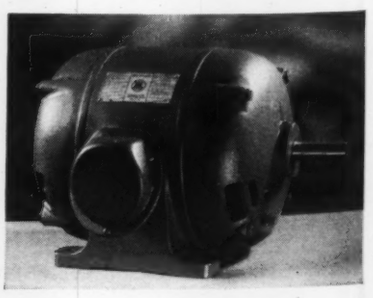
tensile strength of the panel sheets by pulling them into tension between framing members. This tension binds the entire structure rigidly together and the sheets are fastened to the framing without the use of rivets or welds.

High Nickel Alloy Machines Easily

KNOWN as KR monel, an addition to the group of high nickel alloys made by International Nickel Co. Inc., New York, is announced. It has high strength, can be fabricated in automatic screw machinery, resists corrosion, and can be heat treated after fabrication to provide an extra measure of strength and hardness. This alloy is being produced in rod and wire forms only. KR monel was developed to offer a metal with free machining qualities along with physical properties similar to K monel. It is nonmagnetic and has the corrosion resistance common to nickel alloys. Its machining qualities result from special heat treatment.

Smaller Induction Motors Announced

SMALLER ball-bearing induction motors especially designed for general purpose drives are announced by Westinghouse Electric & Mfg. Co., East Pittsburgh.



Induction motors have ball bearings which require lubrication only once in three years

These new CS motors, like the sleeve-bearing models announced last month (M. D. p. 84) are available in

For Designers Who Want A LOW-SPEED MOTOR WITHOUT GEARS

WHAT THIS MOTOR WILL DO FOR YOUR PRODUCT

Reduce number of parts
Reduce maintenance
Reduce weight
Permit greater compactness

HAVE YOU heard about our small low-speed synchronous inductor motor that was announced about a year ago? If not, here's an important message for you.

Here is a motor, 75 or 100 rpm, available in torque ratings of 75, 40, 20, and as low as 2 oz-in. Because of its inherent low speeds, it can often eliminate the need for gears. It is compact and quiet and makes possible easy assemblies. Furthermore, its low speeds and excellent bearing design makes frequent lubrication unnecessary.

This motor has rapid acceleration and deceleration. And if you desire to reverse it, frequency of reversal has no appreciable effect on the operating temperature.

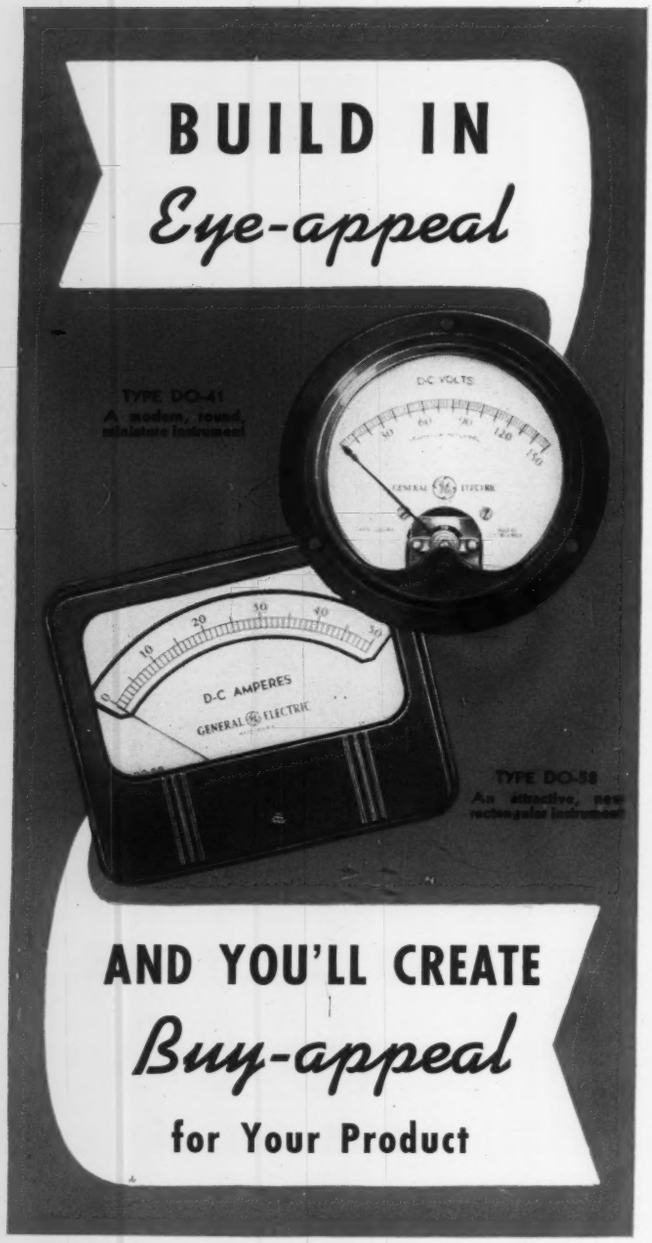
There are the essential facts about this little motor. Many applications of these motors have already been made and many more are being considered. We suggest that if you have a job with torque requirements which fall within the ratings listed, give details to our local representatives. They will be glad to co-operate with you in arranging a demonstration to see if this motor meets your requirements. General Electric Co., Schenectady, N. Y.

RATINGS:

20 oz-in. at 75 rpm in 50L frame
40 oz-in. at 75 rpm in 50H frame
75 oz-in. at 75 rpm in 54H frame
2 oz-in. at 100 rpm in 20 frame
*48 oz-in. at 1 rpm in 20 frame
*24 oz-in. at 2 rpm in 20 frame
*12 oz-in. at 4 rpm in 20 frame

*Obtainable by means of built-in gear reduction

GENERAL ELECTRIC



YOU will add to the attractiveness of your machines if you equip them exclusively with General Electric instruments. They are carefully designed to enhance the appearance of apparatus in which they are incorporated.

Then too, G-E instruments are accurate, reliable, and built to give years of long, hard service. Any way you look at it, they can be a hard working factor in giving more buy-appeal to the products you manufacture.

A full line of standard instruments in all shapes and sizes is available. It will pay you to put your instrument problems up to the nearest G-E office. General Electric, Schenectady, N. Y.

GENERAL ELECTRIC

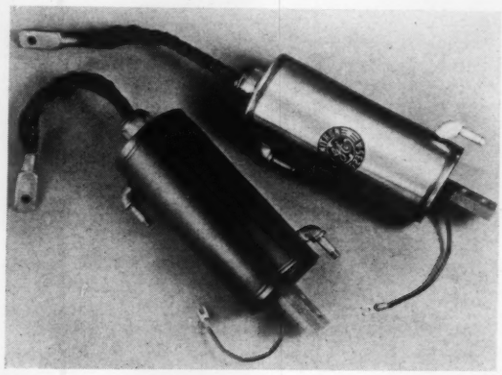
ratings from ½ to 5-horsepower, with speeds from 875 to 3600 revolutions per minute, for operation on 110, 220, 440 and 550 volts, 2 and 3-phase, alternating current. Greatest of the many improvements is the use of "permanently sealed" ball bearings requiring lubrication only once every three years.

Thermostat Suitable for Heavy Duty

COMPRISING a thermostatic element suitable for electrical heater loads of 1500 watts at 115 to 230 volts alternating current, a heavy duty BX strip type thermostat is announced by the George Ulanet Co., 88 East Kinney street, Newark, N. J. The thermostat is available for maximum temperatures of 300, 450 and 700 degrees Fahr. It is supplied with normally closed contacts to open with rise in temperature, or normally open contacts to close with temperature rise.

Ignitron Tubes Resist Corrosion

RECOGNIZING the importance of appearance, General Electric Co., Schenectady, has redesigned its ignitron tubes for resistance welder control. These tubes now have both inner and outer jackets of stainless steel and are completely corrosion-resistant. They carry very high peak currents for short periods, an important characteristic since resistance welding depends on high currents to develop the necessary heat and the control must respond instantly.



High peak currents for short periods are carried by redesigned ignitron tubes for resistance welder control

Announce Program Switch

AN AUTOMATIC program switch, synchronous motor-driven, which can be preset to close a circuit for from 5 to 25 seconds at any 5-minute intervals of 24 hours is announced by the R. W. Cramer Co. Inc., Centerbrook, Conn. Its dial is divided into minutes, halves and twelfths, one division thus corresponding to 5 seconds. The switch can be set accurately to the second and since the main contact is actuated by a double cam integral with this dial the switching is exactly as accurate as the setting.

Engineering Dept. Equipment

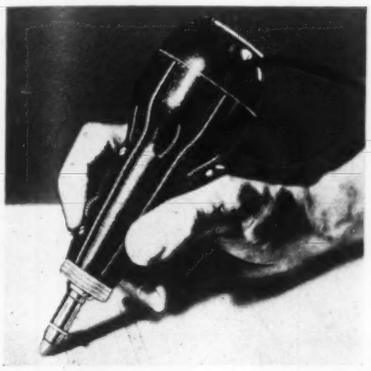
Drawings Printed on Aluminum

A PROCESS known as photo-sensitized metal is announced by Republic Engineering Products Inc., 480 Lexington avenue, New York. Aluminum is coated with an emulsion which permits making copies by the contact printing method, or with an enlarger from an

ordinary drawing, print or negative. Usual steps of development and fixation followed in processing ordinary film are recommended, using standard developers and fixatives. No special darkroom is required. Distortion caused by unequal expansion and contraction is said to be eliminated. For making permanent records, the coated aluminum will withstand high temperatures and can be made moistureproof. Drawings may be modified without changing the master drawing in any way.

Electric Eraser Announced

EMBODYING a "core feed" principle, an electric eraser is announced by the Charles Bruning Co. Inc., 100 Reade street, New York. It uses an eraser 7 inches long, fitting in to a tubular armature shaft. The motor unit is especially designed for the machine and has an

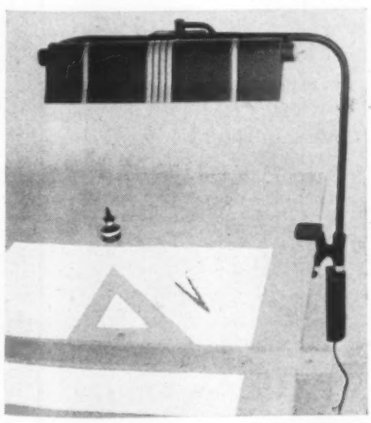


Eraser seven inches long fits into tubular armature shaft in electric eraser

impeller-type fan mounted on the shaft within the lightweight die-cast aluminum motor housing, insuring cool operation. A convenient sliding control button, designed to fit under the index finger, simplifies operation. The long, cylindrical eraser can be fed out as it wears down and tightened at the lower end of the instrument by a chuck.

Gives Cool, Non-Irritating Light

WITH a special pigment-treated reflector that balances the heavy, irritating light common to fluorescent lighting, an engineer's fluorescent light is announced by the Frederick Post Co., P. O. Box 803, Chicago. Tests have shown the light produces two and a half



Cool illumination from fluorescent light permits working close to it without irritating heat

times the light intensity of an incandescent light using an equal amount of power. Cool illumination from the light permits working close to the light source without irritating heat. Quick, positive adjustments set the

To Get More Work from Your Present Equipment

USE these G-E time meters to measure the running time of your electrically operated machines. For when you know how long machines actually operate during each shift, you can arrange more efficient work schedules and increase output.

Time-meter records also enable you to establish definite schedules, based on operating time, for servicing your equipment. This helps to avoid costly delays and shutdowns.

In many other ways, time meters can aid you in lowering costs and increasing profits.

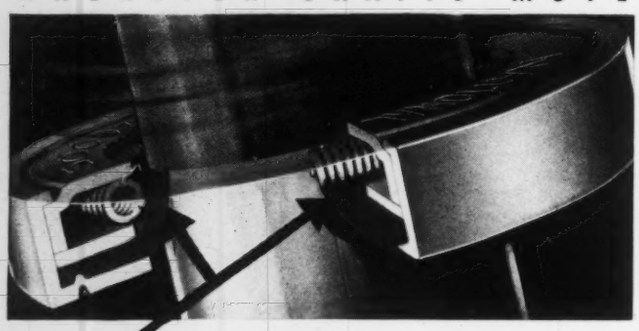
G-E time meters are available for panel mounting, or for easy conduit mounting directly on the machine. Telechron motor operation assures accuracy and dependability.

For additional information, ask the nearest G-E sales office for bulletin GEA-3299, or write General Electric, Schenectady, N. Y.

HEADQUARTERS FOR ELECTRICAL MEASUREMENT

GENERAL ELECTRIC

WHEREVER SHAFTS MOVE



THE MOST IMPORTANT PART OF ANY OIL AND FLUID SEAL IS ITS FLANGE and Wiping Lip IN SEALING SHAFTS AND BEARINGS

Seals are alike, yet different! They might look alike—but it's their *sealing flange* that makes the *real* difference. The wiping lip of a flange is actually the part of a seal that does the sealing. Seals should therefore be *carefully judged* for effective sealing qualities—*on the merits of the flange*. Because of the proven superiority of *Nationalized Leather Flanges*, National Seals differ from other well known makes. Through National's special scientific treatment, Nationalized Leather is impregnably fortified—lastingly preserved and vastly improved to withstand fatigue, abrasion and wear.

NATIONALIZED LEATHER INSURES POSITIVE "SHAFT-FOLLOW" AND SENSITIVE "SHAFT-CONTACT" THROUGH LIVE FLEXIVE TENSION

Through greater lasting resiliency, Nationalized Leather Flanges maintain the correct fluid-tight contact with the shaft at all times. Nationalized Sealing Flanges are firm, yet flexive—tough, yet sensitive. Because of this tested and proven sealing ability, more engineers every day are incorporating National Seals into their designs. If you are not among the many who consider National Seals the advanced improvement—write for complete engineering data.

OF INTEREST TO DESIGNING ENGINEERS

Before you specify or buy any seal, you should have the details on National Seals. Write for your copy of Catalog 44 today.

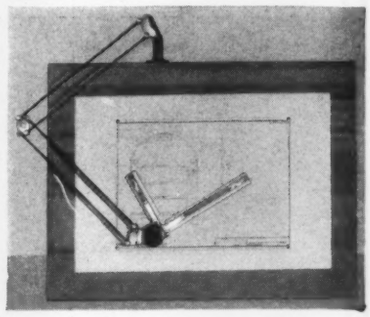
NATIONAL Oil & Fluid SEALS

NATIONAL MOTOR BEARING CO., INC.
1110 - 78th Avenue, OAKLAND, California
Branch Offices: 477 Selden Ave., DETROIT • 2236 South Wabash, CHICAGO

swivel arm at any position from the table top to 24 inches. The shade is adjustable in a horizontal arc 360 degrees and in a vertical arc of 180 degrees. The light is available in two models, with clamp as illustrated or with screw anchor attachment for permanent installation.

Drafting Machine Announced

LIGHT in weight, a low-priced drafting machine is announced by the Drafto Co., 181 Walnut street, Cochranton, Pa. It is designated the Master-Drafto model No. 60, and takes a maximum size sheet of 24 by 36 inches. Arms are seamless steel tubing, fitted with solid bearings. For center mounting the machine on a drafting board or table, a cast aluminum bracket is used. Its protractor device is outstanding,

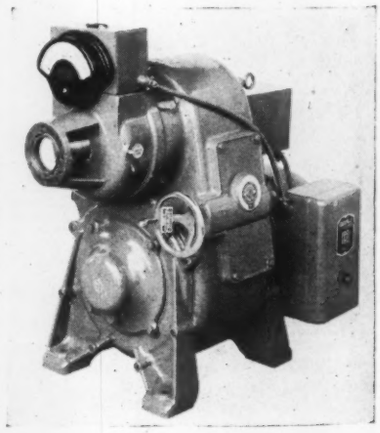


Protractor of drafting machine can be locked at any degree, but latching spring locks scales at common points

the plate being graduated in 2 degrees, and can be set accurately for ½-degree readings by use of the graduated vernier. The protractor can be locked at any degree, but for speed and convenience it is fitted with a latching spring to lock the scales at 0, 30, 45, 60 and 90 degrees on either side of the 0 degree reading.

Stand Provides Testing Speeds

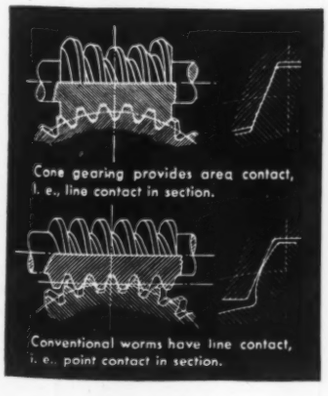
A VARIABLE speed Speed-trol test stand especially designed for testing of parts such as generators, pumps, alternators, etc., is announced by Sterling Electric Motors Inc., Los Angeles. This unit provides positive speeds necessary for checking and predetermining the behavior at normal and overspeeds of all such



Test stand is designed for testing parts like generators, pumps and alternators

parts. Standard units are designed for constant service and are furnished with 5-horsepower motors and provide infinite speeds from 1000 to 5000 revolutions per minute without the aid of gears on the output shaft.

"Smoother Operation" with CONE-DRIVE


Cone gearing provides area contact, i. e., line contact in section.
Conventional worms have line contact, i. e., point contact in section.

CURRENT CONE OPERATING RANGES
Ratios . . Low, 1 to 6; High, 180 to 1.
Speed, Low 1/15 rpm., High 30000 rpm.
Sizes (C.D.) Low, 5/8 in.; High, 27 1/2 in.

"To further improve the smoothness of an already well known smooth running machine", the Foster Machine Company, Westfield, Massachusetts, has adopted Cone-Drive Worm Gearing for the reduction drive of its Model 102 Knitting Cone and Tube Winders.

Smooth operation is vital to the action of these machines, which wind the cones of yarn used in manufacturing knitted textiles. Cotton and mercerized yarns, yarns of Rayon and Nylon—all must be smoothly wound, with just the right amount of tension to draw from the cone into the knitting machine.

For these machines the Cone-Drive has a worm to gear ratio of 64 to 1, with centers only 2.750 inches apart. The gears are single thread, must operate with minimum backlash and are interchangeable.

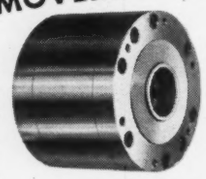
A larger number of teeth in contact with vastly greater contact area increase load-carrying capacity as well as improving quietness and smoothness when Cone-Drive gears are used. Reduced size and weight, longer life in service, and greater efficiency (most efficient worm drive units known) are further advantages.

We would be pleased to send you complete information about the application of Cone-Drive Gearing to your speed reduction problem. Ask for engineering bulletin CW-41C.

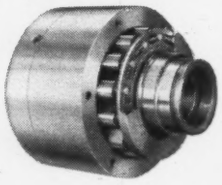
CONE WORM GEAR DIVISION
MICHIGAN TOOL COMPANY
7171 E. McNICHOLS ROAD, DETROIT

"SUCCESS"

PROVEN BY 20 MILLION RATCHET MOVEMENTS!



AGAIN, Morse Indexing Free-Wheeling Clutches prove their worth to efficient production management . . . 120 times a minute, 20 million ratchet movements a year, and always going strong—another case history of a Morse Clutch installation on a large hex nut punching press . . . requiring absolute dependability and accurately controlled ratcheting.



Morse Free-Wheeling Clutches and Clutch Couplings are automatic, foolproof and efficient; adaptable to a wide range of applications. The perfect clutch that free-wheels smoothly and automatically.

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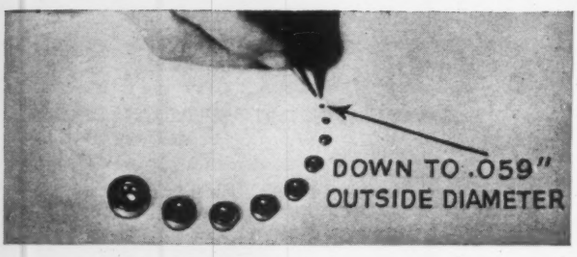
MORSE CHAIN COMPANY, ITHACA, N. Y. • DIVISION BORG-WARNER CORP.

R. M. B. *Miniature Ball Bearings*



These unique small bearings are ideal for all kinds of instruments, precision tools, motors, indicators, oscillators, timing and weighing devices, and any number of other mechanisms having small moving parts.

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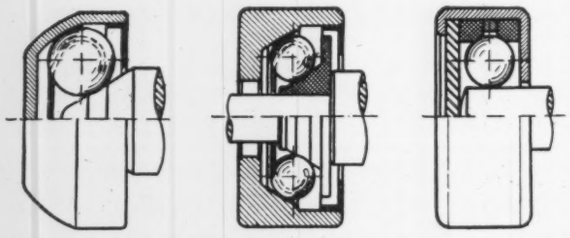


These **enlargements** show a few of the many series . . . available in a wide variety of sizes.

Meetings and Expositions

Jan. 31-Feb. 1—

National Scale Men's association. Annual meeting and exhibit to be held at St. Paul hotel, St. Paul. R. O. Rask, 916 West Grove street, Bloomington, Ill., is secretary-treasurer.

Feb. 12-13—

Steel Founders Society of America. Annual meeting to be held at Edgewater Beach hotel, Chicago. R. L. Collier, 920 Midland building, Cleveland, is secretary.

Feb. 17—

National Electrical Manufacturers association. Midwinter meeting to be held at Palmer House, Chicago. R. J. Blais, 155 East Forty-fourth street, New York, is convention manager.

March 10-13—

American Society of Bakery Engineers. Annual meeting to be held at Edgewater Beach hotel, Chicago. Victor E. Marx, 1541 Birchwood avenue, Chicago, is secretary.

March 11-13—

American Railway Engineering association. Annual meeting to be held at Palmer House, Chicago. W. S. Lacher, 59 East Van Buren street, Chicago, is secretary.

March 12-13—

American Society of Mechanical Engineers. Special national meeting on defense to be held at Statler hotel, Cleveland. C. E. Davies, 29 West Thirty-ninth street, New York, is secretary.

March 17-22—

Oil Burner institute. Annual meeting to be held at Benjamin Franklin hotel, Philadelphia. C. F. Curtin, 30 Rockefeller Plaza, New York, is secretary.

March 25-29—

American Society of Tool Engineers. Machine and Tool Progress exhibition to be held at the Convention Hall, Detroit. Additional information may be obtained from Ford R. Lamb, 2567 West Grand boulevard, Detroit, executive secretary.

April 9-10—

Midwest Power conference. Meeting sponsored by leading engineering schools, to be held under direction of Illinois Institute of Technology at Palmer House, Chicago. Further information may be obtained by writing the Institute.

April 28-May 2—

American Mining congress. Annual meeting and exhibition to be held in Cincinnati. Julian D. Conover, Munsey building, Washington, is secretary.

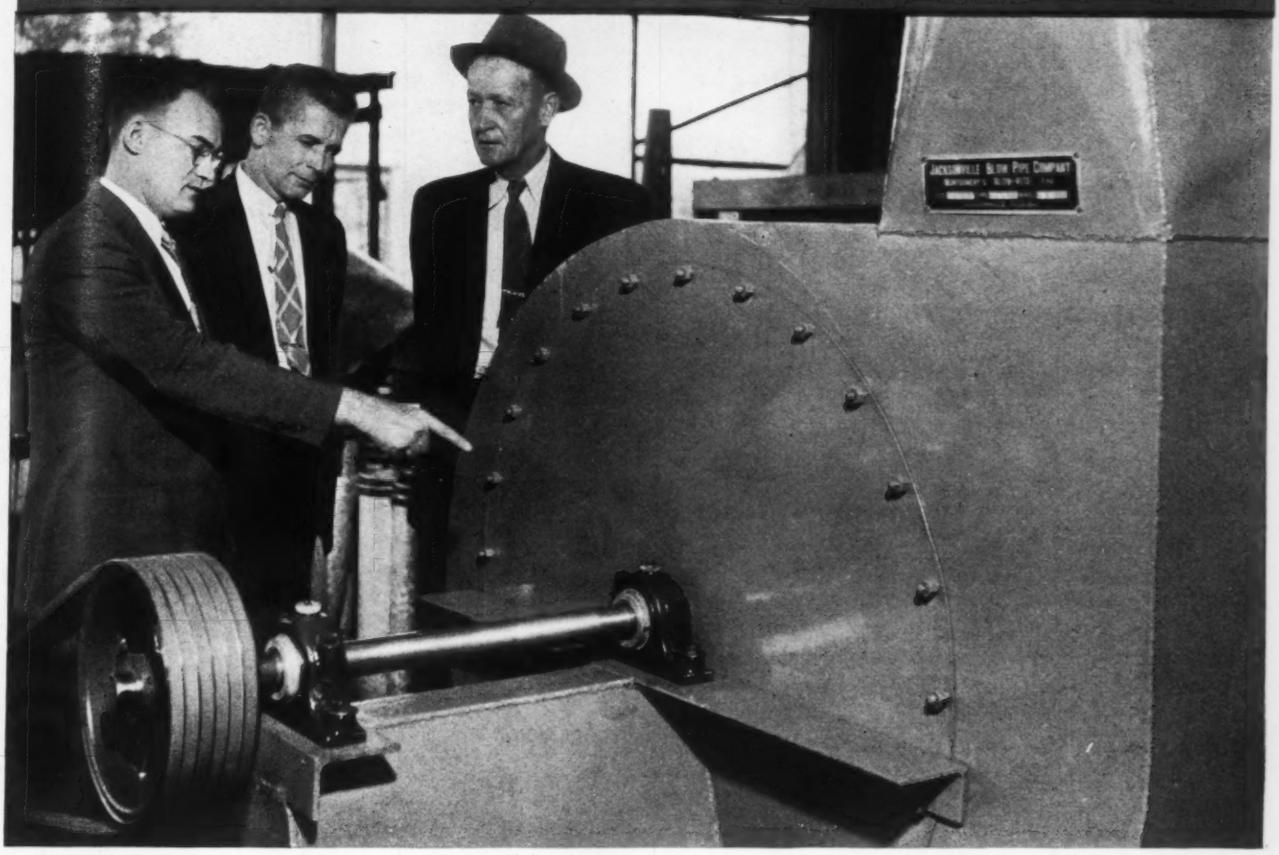
May 5-7—

The American Gear Manufacturers association. Twenty-fifth annual convention to be held at The Homestead, Hot Springs, Va. J. C. McQuiston, 602 Shields building, Wilkinsburg, Pa., is secretary.

May 12-15—

American Foundrymen's association. Annual meeting to be held at Pennsylvania hotel, New York. N. F. Hindle, 222 West Adams street, Chicago, is technical secretary.

You Pay the Same for Power - - Delivered or Dissipated!



"Our Customers Tell Us We Picked the *Right Bearings*"

. . . says Mr. Montgomery

The Jacksonville Blow Pipe Co., Jacksonville, Florida—manufactures exhaust fans that can "take it" — from chips to wet sawdust that get into the pipes . . . these fans ably cope with gruelling service. Naturally the bearings used on these fans must be equally rugged and trouble-free. And they are — for they are Dodge-Timken Double Interlock Roller Bearings . . . known for unfailing operation. Mr. Montgomery, President of Jacksonville Blow Pipe Co. — Mr. Stoner, Dodge Representative, and Mr. King, Dodge Distributor Salesman — "talk over" this installation.

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Mr. King: And they will continue to do so — for Dodge Interlock Bearings are fully self-aligning . . . and are designed to give 30,000 hours of service under conditions for which they are adapted.

Mr. Stoner: Besides, these bearings are effectively "sealed" against dust and dirt and other destructive elements. They are prelubricated and easily mounted.

Mr. Montgomery: One of our customers who used $1000 worth of oil on babbitt bearings says he'll cut this to $50 now. Dodge Double Interlock Bearings are giving us more than double value.

There is a Dodge Rolling Bearing for every industrial service — each one designed for a life expectancy of 30,000 hours under conditions for which they are adapted. Write for selection tables which make it easy to pick the right bearing for any job.

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DODGE
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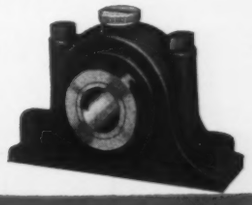
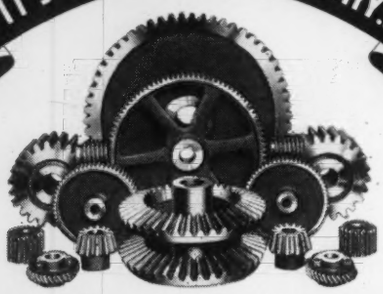
Power Transmission



THE RIGHT DRIVE FOR EVERY JOB

IT'S EASY TO SEE WHY...



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Direction of Rotation
Min. Radius of Shaft Curvature
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Length of Shaft
Operating Conditions

STOW MANUFACTURING CO., INC.
11 Shear St., Binghamton, N.Y.
Established 1875 *Inventors of Flexible Shafts*

Selecting Special Motors

(*Continued from Page* 57)

rotor periphery, making more poles impracticable.

Synchronous-capacitor-induction motors can be built as three-lead reversible motors by making both windings similar. Like the three-lead nonsynchronous motors they are reversed by means of a single-pole double-throw switch, *Fig.* 3*g*. The reversing characteristics and their effects on the running characteristics are similar to those of the four-lead motor, except that the general all around efficiency is lower. All effects due to alterations are therefore more critical.

The speed-torque curve of a synchronous-capacitor-induction motor has its principal shape in common with that of a split-phase synchronous motor, employing a centrifugal starting switch, *Fig.* 6. The motor runs at a fixed synchronous speed from no load to full load. At a certain point beyond full-load torque, depending on its reserve power, it drops out of synchronous speed and runs with marked vibration considerably below synchronous speed. When the load is reduced the motor pulls into synchronism again. The points on the speed-torque curve where these changes occur are usually referred to as pull-out and pull-in, or pull-back torques of the motor.

Polyphase Motors Require Double-Pole Switches

Some very low-powered synchronous motors are available on the market, as used to drive electric clocks, timers and similar applications. They operate on the shaded-pole and hysteresis principles, and are also occasionally designed as reversible motors. The scope of this discussion is limited to larger motors, about 1/2000 to ¼ horsepower.

POLYPHASE-INDUCTION AND POLYPHASE-SYNCHRONOUS-INDUCTION MOTORS: A two-phase induction-motor has two identical windings displaced ninety electrical degrees, with two terminals attached to each winding. The direction of rotation is reversed by reversing the current through either winding by means of a double-pole double-throw switch, see *Fig.* 3*h*. No practical scheme exists for reversing a two-phase or three-phase motor by means of a single-pole double-throw switch.

A three-phase induction motor incorporates three identical windings displaced 120 electrical degrees from each other. The windings are connected either in star or delta. Usually only three terminal leads are brought out of the motor. Direction of rotation is reversed by interchanging any two of its lead connections to the line by means of a double-pole double-throw switch, *Fig.* 3*j*.

Starting and reversing torque characteristics of polyphase motors are exceptionally good. They run more efficiently than any single-phase motor, and their speed-torque curves are relatively flat, with little slip at full load.

Polyphase motors are also built in synchronous construction. These motors usually demonstrate good pull-out and pull-in torques, considering that even a

SINGLE REDUCTION
Westinghouse Type S, single reduction, explosion-proof gearmotor. (Standard ratios 1:12 to 5:1). This type available for all types of enclosures.
DOUBLE REDUCTION
Westinghouse Type D, double reduction gearmotor. (Standard ratios 5.6:1 to 10.0:1). Compact design is the result of building reduction gears and motor as one complete unit.
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FOR EVERY TYPE
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Westinghouse Type FD, double reduction gearmotor. (Standard ratios 10:1 to 40:1). This splash-proof enclosure and other special enclosures are available throughout the line.
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GEARED DRIVES
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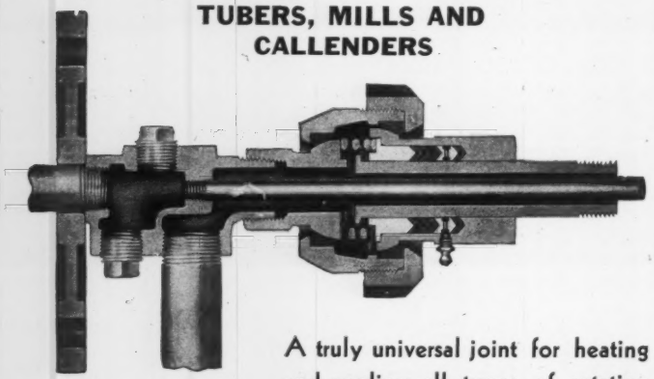
TUBERS, MILLS AND CALLENDERS



A truly universal joint for heating and cooling all types of rotating rolls. Eliminates packing troubles due to strains in ordinary stuffing boxes.

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TECHNICAL SPRING TREATISE

which gives the engineering story of springs and how to order them. Catalog will be included. Please write on your letter head.

PECK SPRINGS
AND SCREW MACHINE PARTS
The Peck Spring Co. 10 Wells St., Plainville, Conn.

polyphase synchronous motor exhibits the tendency of the rotor poles to lock magnetically with the stator teeth.

The accompanying table summarizes the essential characteristics of reversing motors of the types discussed. To select a reversible motor for a grinding wheel dresser, for instance, knowledge of the tabulated characteristics of each motor leads to the proper choice.

Does the motor have to be capable of reversing instantly from full speed forward to full speed reverse, or can it always come to rest before reversing? Assuming that instant reversibility is highly desirable for this particular machine, is a constant speed motor required? Is it necessary to vary the speed, or is speed regulation a problem to be considered? For the application in mind, a constant-speed motor with good regulation is needed. Also, motors are required for various currents such as single-phase, three-phase and direct-current.

Since instant reversibility is necessary, the motor selected should not have a centrifugal starting switch. It need not be a synchronous motor. Good speed regulation is a factor, therefore a series-wound motor cannot be used. The choice is narrowed down to the capacitor-induction type of motor for single-phase. Should it be a three-lead or a four-lead motor? The single-pole double-throw switch required for a three-lead motor is lower priced and simpler to connect. However, a double-pole double-throw switch is needed for the four-lead motor, and probably for the direct-current motor. Then too, a smaller capacitor for the same output can be used if a four-lead motor is selected. With so many factors in favor of a four-lead motor, and so little in favor of a three-lead motor, the former probably would be selected.

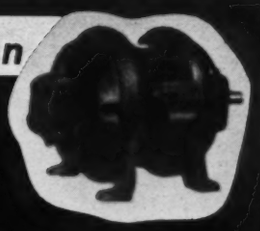
If, however, a three-phase motor is required, the choice is simple because a synchronous motor is not essential. The process of elimination leads to the selection of a three-phase induction-motor.

For a direct-current application, the series-wound motor has already been ruled out. The direct-current choice must be between a shunt or a compound winding. Both take the same frame size. The compound winding gives quicker reversibility, but the shunt winding gives slightly better speed regulation. For the purpose, however, the regulation of the compound-wound motor is sufficient. Both use the same type of reversing switch. Advantage, therefore, can be taken of the quicker reversing feature offered by the compound wound motor.

As in the foregoing, there usually are several motors from which to select. One of them, however, is the best when all factors of design, economy and utilization are weighed.

To meet a long-felt need for a standard of accuracy, the builders of engine lathes have adopted a set of tolerances to which the industry is building toolroom and engine lathes. Included also in the standard are tests by which these tolerances may be checked. It is anticipated that this standard will be accepted by the American Standards association.

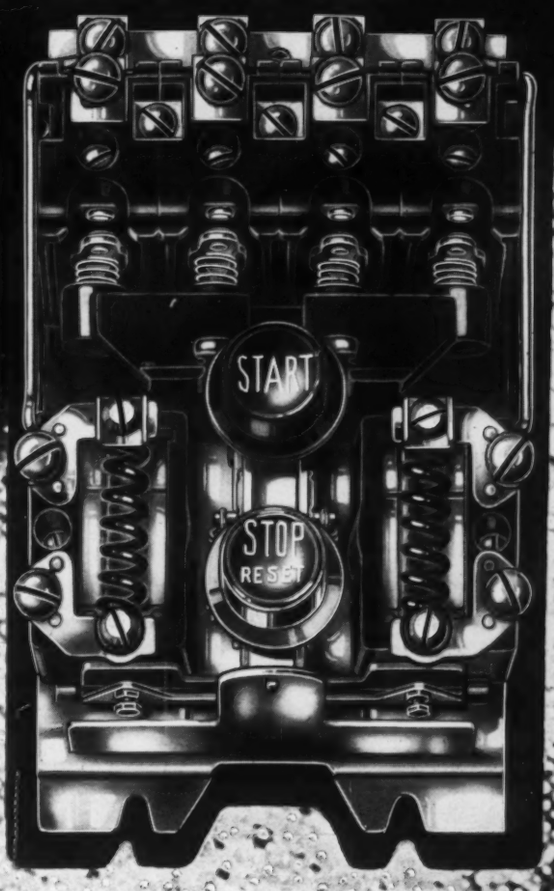
For Motor Control and Overload Protection



Re-settable Thermal Switches

ARROW H&H

Manually operated



To be "*right* from the start" your machines must *START* RIGHT by the dependable functioning of motor controls. These ARROW-H&H Thermal Switches give machines the right "START"— and *keep* them running without risk of motor overloads and down-time.

Handy front-operating manual control, with "Start—Stop-Reset" Push-buttons. Thermal overload protection (in different ratings) for motors up to 7½ H. P., 440-550 Volts... Fifty years of fine switchmaking — as exemplified here — brings any machine under the best of *control!*

FEATURES: Across-the-Line Type (Type RT), manually controlled, front-operated. STRAIGHT-LINE LINKAGE mechanism; no wipe on contacts, minimum of mechanical wear. Contacts silver to silver butt type. Movable contacts full-floating, self-adjusting. Thermal overload protection by bi-metallic action with interchangeable heaters. Mechanism trip-free from the thermal relay. 2, 3 and 4-pole switches... each pole a unit in Bakelite. Easy to wire:—merely loosen three screws to take switch unit out of box. You'll find the full-line specifications in Catalog 8-M, on request. Please use our free Engineering Service to plan arrangements of our *standard units* to meet your *special* requirements in motor controls.

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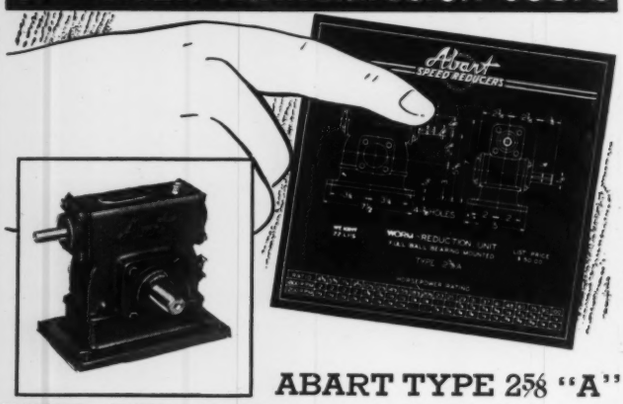
PUTS THE FINGER
ON POWER TRANSMISSION COSTS



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SPEED REDUCER *Handles Wide Range of Work*

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Abart GEAR AND MACHINE CO.
MANUFACTURERS OF
Speed Reducers & Gears
4821 WEST 16TH ST. CHICAGO, ILLINOIS

Designing Open-Coiled Springs

(*Continued from Page* 66)

most compression springs where the friction between the ends and the supporting plate prevents relative rotation. For large deflections of tension springs where the hooks tend to restrain the ends from rotating, it also applies. In this case it is necessary to take into account the moment acting at the ends which tends to prevent the coil from unwinding.

From the theory of elasticity[4] the following expressions are obtained for the load and constraining moment M_0 at the spring ends:

$$P = GI_p \frac{\cos\alpha}{r}\left(\frac{\sin\alpha\cos\alpha}{r} - \frac{\sin\alpha_0\cos\alpha_0}{r_0}\right) - EI\frac{\sin\alpha}{r}\left(\frac{\cos^2\alpha}{r} - \frac{\cos^2\alpha_0}{r_0}\right) \quad (21)$$

and

$$M_0 = GI_p \sin\alpha\left(\frac{\sin\alpha\cos\alpha}{r} - \frac{\sin\alpha_0\cos\alpha_0}{r_0}\right) + EI\cos\alpha\left(\frac{\cos^2\alpha}{r} - \frac{\cos^2\alpha_0}{r_0}\right) \quad (22)$$

In addition, since the ends of the spring are prevented from rotating, $\phi_2 = \phi_1$ from Equations (17) and (18). From this

$$r = r_0\frac{\cos\alpha}{\cos\alpha_0} \quad (23)$$

By using Equation (23) in Equations (21) and (22) the deflection may be expressed in a similar way as was done for the case where the ends are free to rotate. The results are given in *Fig.* 9, a deflection correction factor ψ_1' being used. This factor is again plotted as a function of δ_0/nr_0 and of α_0. Comparison of *Figs.* 6 and 9 indicates that the difference between the two cases (ends fixed or free), is not great at smaller values of δ_0/nr_0. At larger values there is some deviation.

Buckling Is Not Considered

Load-deflection diagrams as determined for compression springs with fixed ends by using *Fig.* 9 are given in *Fig.* 10. At the larger pitch angles and deflections there is considerable deviation from the straight line calculated by the usual formula. The question of buckling of compression springs is not considered here[5]. Where the buckling load is exceeded, the curves of *Figs.* 9 and 10 may still be used if guides of some kind are provided to restrain the spring laterally.

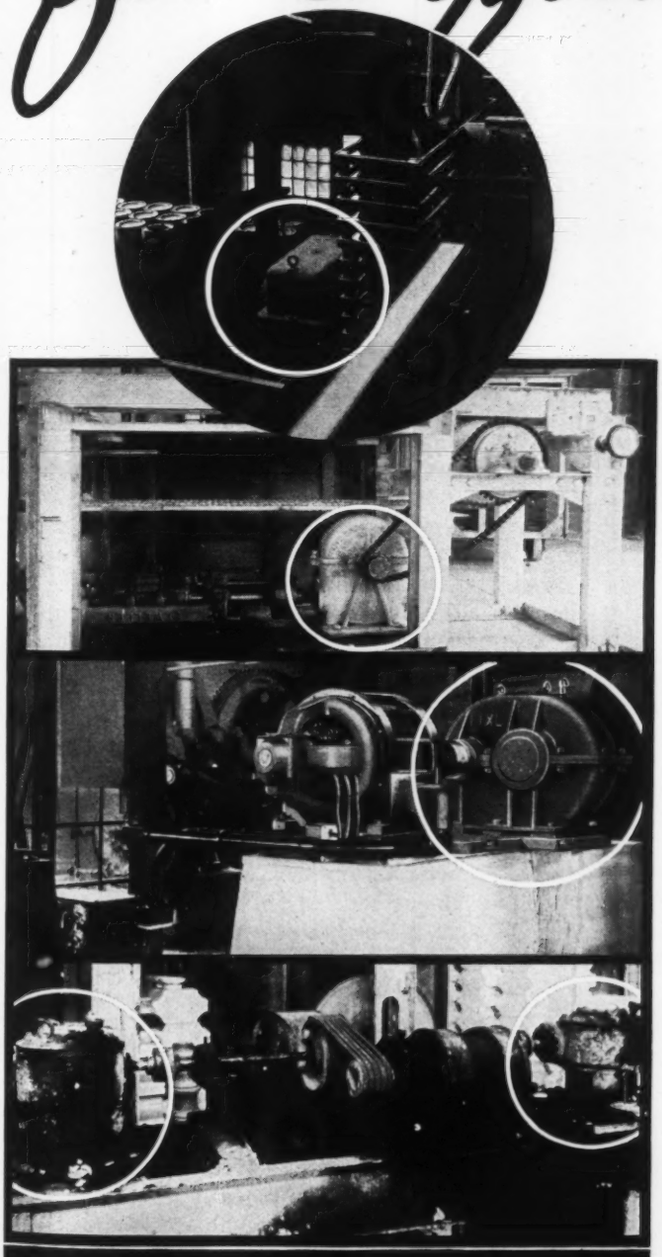
Similar curves for tension springs with ends restrained from rotation about the spring axis are given in *Fig.* 11. This condition will apply for tension springs

[5] Formulas for calculating buckling loads of compression springs are given in the writer's article, MACHINE DESIGN, March, 1938.

(*Concluded on Page* 132)

IXL SPEED REDUCERS *for Defense*

OF PRODUCTION SCHEDULES!



EVERY day . . . every hour . . . every minute counts in this big job that industry has before it. Your plant has its part to play—a vital part! Maybe not guns or ships, or tanks, but something which industry depends upon. Something we *all* depend upon. That "something" you supply must fit into production schedules that are growing faster—faster.

That problem is the reason why you'll want to incorporate into the machines you build, Speed Reducers that can be depended upon not to cause trouble and wasted hours. It's the reason we'd like to remind you that IXL Speed Reducers and gearing will keep things continually humming. They'll safeguard the quality and dependability you put into your products.

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COMPLETE ENGINEERING SERVICE

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KROPP

KROPP FORGE COMPANY

World's Largest Job Forging Shop

5307 W. Roosevelt Road, Chicago, Ill.

Representatives in Principal Cities

(*Concluded from Page* 126)

having hooks which fit into holes in end plates so that when the spring is extended the hooks cannot rotate appreciably. It also holds where the spring is fitted with spring ends fastened in a mechanism which prevents the ends from rotating.

Equivalent Stress Calculated Similarly

CALCULATION OF STRESS—ENDS FIXED: The equivalent stress may be calculated in a similar way as was done for the case with ends free to rotate. From *Figs.* 2 and 3, the bending moment acting at any point on the spring is:

$$M_b = M_0 \cos \alpha - Pr \sin \alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (24)$$

Likewise the twisting moment is:

$$M_t = M_0 \sin \alpha + Pr \cos \alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (25)$$

From these the bending and shear stresses S_b and S_s may be calculated as before. Using Equations (21), (22) and (23), the equivalent stress may be expressed in the following form:

$$S'_{se} = \frac{16Pr_0}{\pi d^3} K'_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (26)$$

where K_2' depends on the ratio δ_0/nr_0 and on α_0 as before and may be read from curves of *Fig.* 12.

As a result of the study upon which this article is based, the curves used were prepared to provide a simple and more accurate method of calculating deflections in axially loaded, open-coiled helical springs subject to large deflections. These charts take into account not only the effect of large initial pitch angles but also that of change in pitch angle and coil radius as the spring deflects. For springs of large index where the initial pitch angle is below 10 degrees and the deflection per turn less than half the coil radius, the results indicate an error in the ordinary deflection formula under 3½ per cent. However, as the initial pitch angle and deflection increase, the error increases, approaching 15 per cent for initial pitch angles near 20 degrees and deflections per turn equal to the coil radius. Charts are also given for calculating the twist of the ends of open-coiled springs under load. For best accuracy in the design of open-coiled springs, or those subject to large deflections, it is advisable to take these effects into account.

Information on 952 standards as of December 1, 1940, is given in the latest edition of the Index to A. S. T. M. Standards. The index is of service to designers wishing to ascertain whether the society has issued standard specifications, test methods, or definitions covering a particular engineering material or subject. Further, it is of help in locating the standards in the volumes where they appear.

All items are listed in the index under appropriate key words according to the subjects they cover. As a convenience a list is given of the specifications and tests in numerical sequence of their serial designation.

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Machine Fastenings in Design

(*Concluded from Page* 61)

minum alloys, brass or bronze for the same reason. Other insert materials such as nickel alloys, piano wire or beryllium copper may be used.

Constituting a notable improvement over ordinary taper or nordberg pins, the pin fastenings illustrated in *Fig.* 17 are completely resistant to loosening under the most severe conditions of vibration. Effectiveness of the locking properties of the pins is based on the grooving principle which is utilized through three evenly spaced grooves in a cylindrical pin. The grooves are rolled and pressed into the pins, thereby upsetting and displacing the stock with a resulting expansion of the pin circumference to specified limits for the various sizes. This deformation takes place mainly adjacent to the grooves but also, to a lesser extent, in the portion between them.

Outstanding among its advantages is the fact that these pins require only a drilled hole of the proper size for insertion. Reaming to close tolerances and finish, as for taper or straight pins, is unnecessary.

Inherent resilience of the bulges of the pin manifests itself especially in assembly applications which must be occasionally demounted and re-assembled. Tests have revealed that the loss of holding efficiency after fifty insertions and withdrawals of the same pin is less than fifty per cent.

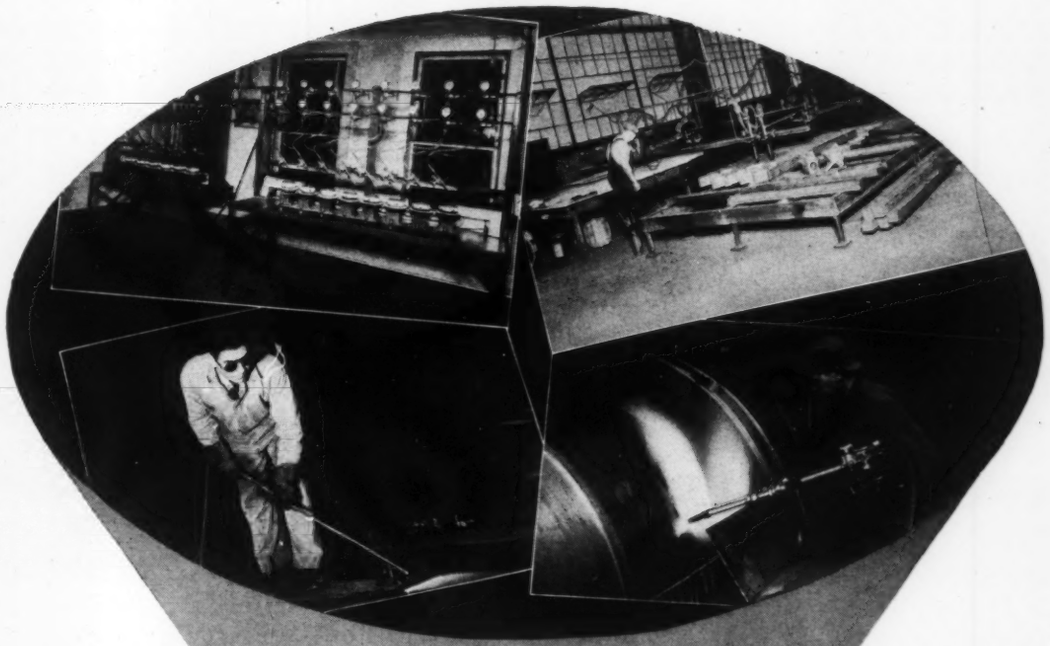
As normally made of cold drawn bessemer screw stock (S.A.E. 1112) the pins have a tensile strength of 85,000 to 100,000 pounds per square inch and a shear strength of 65,000 to 80,000 pounds per square inch. They are available also in chrome vanadium steel (S.A.E. 6150). Properly hardened and drawn of this material they have a tensile strength of approximately 200,000 pounds per square inch.

Furnished to be used as spring anchors and the like they are also supplied with a reduced section near one end. Headed drive studs utilizing the same groove feature are also obtainable and are used as hinge pins on door assemblies, to fasten tube and cable clamps, to fasten the lining to brake shoe castings, etc.

The fastening of rubber, insulating material, fabric, light sheet, etc. to steel in thicknesses up to 18 gage may be accomplished by the wire stitching process shown in *Fig.* 18. In this illustration, fabric is being fastened to the steel frame of a seat cushion. Formerly done by the use of an adhesive, the stitching process effected an increase in production of about 1300 per cent and practically eliminated rejects.

In this process prepunching of holes is unnecessary. A hard grade of wire is used which acts as a punch as the stitch is being formed and drives out a slug.

MACHINE DESIGN is glad to acknowledge the contributions of the following companies to this article: Aircraft Screw Products Co.; Allen Manufacturing Co.; American Screw Co.; Groov-Pin Corp.; Harris-Seybold-Potter Co.; Holo-Krome Screw Corp.; Strong, Carlisle and Hammond Co.; National Machine Products Co.; Russell, Burdsall and Ward Co.



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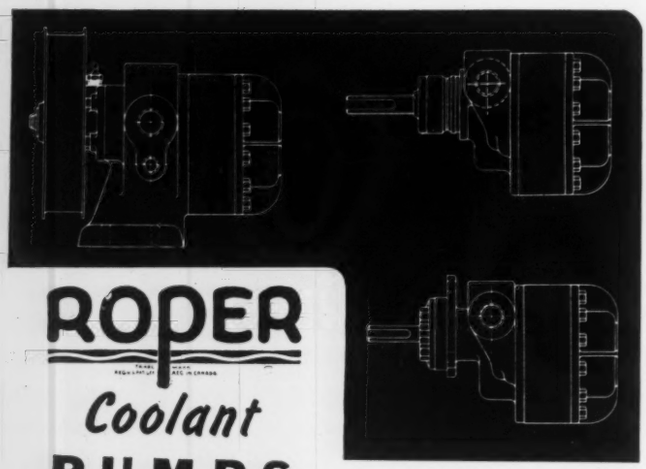

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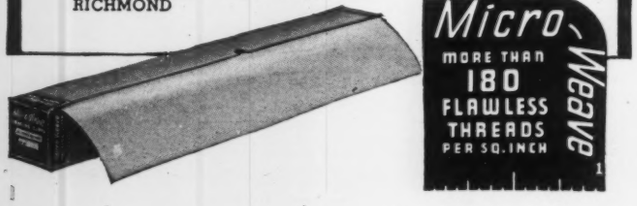


Professional Viewpoints

(*Concluded from Page* 73)

engineering, it may prove of value to designers.

A reliable guide of this kind is helpful. Should the radius of bend be too small, scarred and otherwise unsatisfactory surfaces will be the inevitable result. The curves have been developed from the following considerations:

$$S_b = 60000\ lb./sq.\ in.$$

$$S_c = \frac{1}{3}\,60000 = 20000\ lb./sq.\ in.$$

$$S_b = \tfrac{1}{2}\,MT/I$$

$$I = T^3/12$$

$$S_b = 6M/T^2$$

At the start of the forming operation a line contact is created between the forming block, having a radius R, and the bottom of the stock. If a width of stock equal to unity and a line contact are assumed, an infinitely small area would be obtained. This would allow an infinitely small pressure only and prevent further analysis. The assumption is therefore made that the radius R will deform the under surface of the stock for a length of .01-inch and in this short distance the radius R is assumed to be straight.

Therefore an area of 1 x .01 = .01 square inch is taken and the safe allowable pressure on this area = 20,000 x .01 = 200 pounds.

$$M = 200\,x$$

Substituting in the fifth equation above

$$x = 50\,T^2$$

From the drawing

$$R = x - T$$

Substitution for x gives

$$R = 50\,T^2 - 1$$

Plotting this gives Curve 1 in the accompanying illustration. However, the following equation

$$R = 64\,T^2 - 1$$

gives Curve 2 and, having an added factor of safety, is recommended.

Nomenclature

S_c = Safe compressive stress for mild steel
S_b = Ultimate stress
T = Stock thickness
M = Bending moment
I = Moment of inertia
x = Distance from side of punch to center line of "R". This is also a minimum leg length for the "U" shaped section
R = Radius on corner of die block

Tried in actual practice, the values given on the curves have been applied and carefully observed for several different thicknesses. The practical results substantiated by the mathematical analysis indicates that satisfactory results may be expected over the entire range.

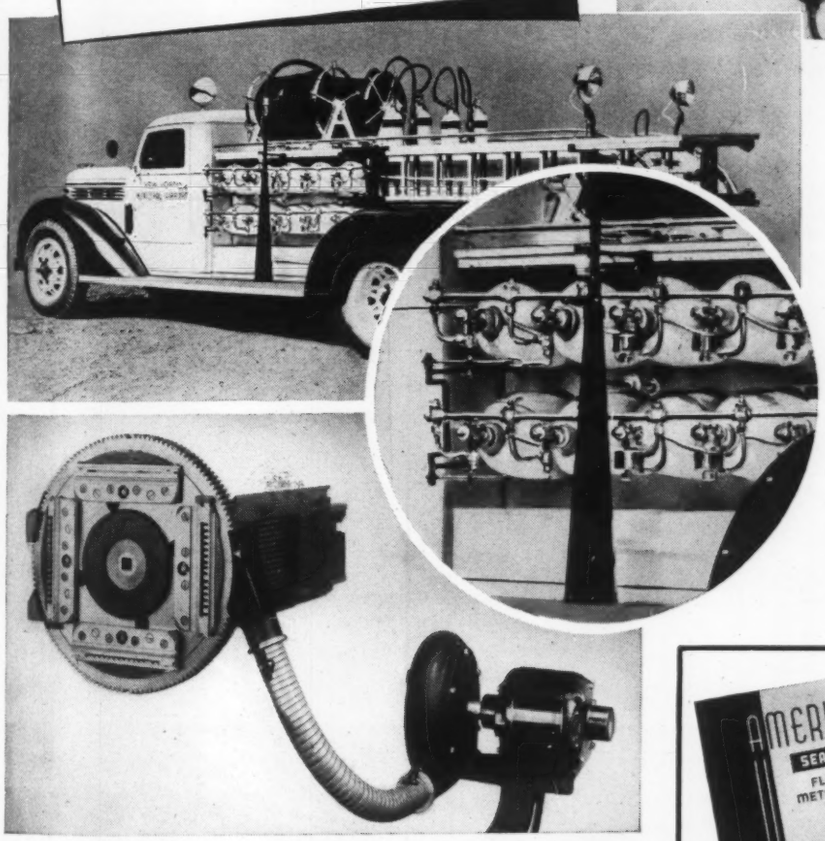
—Louis G. Blumenbaum
Boston Wire Stitcher Co.

See how problems disappear when *Flexible Metal* hose is used!

Electrical disturbances in aircraft radio were a problem until instrument makers found this economical, dependable means of solving it. It is flexible *aluminum shielding conduit* for low tension wiring. Its use not only ended frequency noises, but because the shielding is extremely flexible, it could be bent around tight places and pushed back into corners. This solution to a typical design problem became a U. S. Govt. specification.

•

When Walter Kidde Co., of Bloomfield, N. J., designed this special crash truck for New York's North Beach Airport, there was one important kink—what to use to connect the series of CO_2 tanks you see here? It must be seamless for safety's sake...must be flexible since the tanks were frequently removed for weighing... and must be as durable as the truck itself. The answer, in this, as in thousands of similar cases, was *American Seamless Flexible Metal Tubing.*



The *flexible metal hose* on this blower used in Mergenthaler Linotype machines to bathe linotype molds with cool, clean air in order to keep the temperature just right performs three simple but important functions. Flexible hose can be directed so that air hits exactly where it is needed... it's easier to install... is neat and conserves valuable space.

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Business and Sales Briefs

NUMEROUS changes have been made to strengthen the sales organization of the Bunting Brass & Bronze Co., Toledo, O. William T. Streicher has been transferred to Chicago from Kansas City, and James F. Roberts has moved to Indianapolis from Dallas, Tex. William A. Schneider has been sent to Dallas. John J. Mengler and William Dorsey, new Bunting men, go to Kansas City and Seattle, respectively. Robert J. Bergum, a former Bunting sales engineer, has rejoined the company and will represent it in Minneapolis.

♦

G. L. Irvine has been appointed manager of apparatus agency sales, a new section added to General Electric Co.'s industrial department, Schenectady.

♦

An addition of 56,200 square feet of manufacturing floor space to Plant No. 2, on the Pennsylvania railroad at Bridge street, is announced by SKF Industries Inc., Philadelphia. In addition, a two-story brick wing enclosing 12,000 square feet is extending office facilities at Plant No. 1, Front street and Erie avenue.

♦

Plans for immediate construction of a new centrifugal casting building, doubling the size and equipment of this division, are announced by Ampco Metal Inc., Milwaukee. This is Ampco's fifth expansion during the past twelve months.

♦

Reynolds Metals Co., Richmond, Va., is building a $23,500,000 aluminum plant at Sheffield, Ala. Basil Horsfield will be manager.

♦

Additions will be built immediately to the plants of Doehler Die Casting Co. at Pottstown, Pa., and Batavia, N. Y. The company's main plant at Toledo, O., was recently enlarged.

♦

Expenditure of approximately $400,000 is planned for expansion of the eastern facilities of the Plastics departments of the General Electric Co., according to G. H. Shill, manager of the department. Seventy-five per cent of the expenditure will be made at Pittsfield, Mass., where completion of a new building will permit all laboratory work of the department to be consolidated. The new two-story building will also house administrative offices. At Meriden, Conn., a new building will permit installation of more than 40 additional hot molding presses. The cold molding section also will be modernized. Installation of a new press at Lynn, Mass., will substantially increase output of laminated Textolite there.

♦

Callite Tungsten Co., 544 Thirty-ninth street, Union City, N. J., announces the appointment of Harold M. Malm as factory sales engineer. A former Callite metallurgist, Mr. Malm returns in this new capacity after serving some time as design engineer and metallurgist for the Lee Spring Co., New York. At Callite he will concentrate on special alloy wire applications.

♦

H. A. Scallen has been appointed district manager by Jessop Steel Co., Pittsburgh for the Hartford, Conn., branch. Offices and warehouse are at 626 Capitol avenue. Mr. Scullen has been a representative in New England for Jessop since 1930.

H. F. Robertson has been appointed sales represen-

FLUID DRIVE SUCCESS IN PAPER MILL

Important advantages are reported by the operating staffs of several large paper mills in which American Blower Fluid Drives (Hydraulic Couplings) have been installed for speed control of paper machines.

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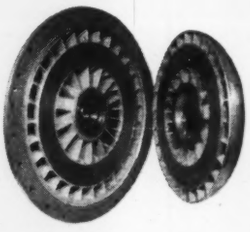

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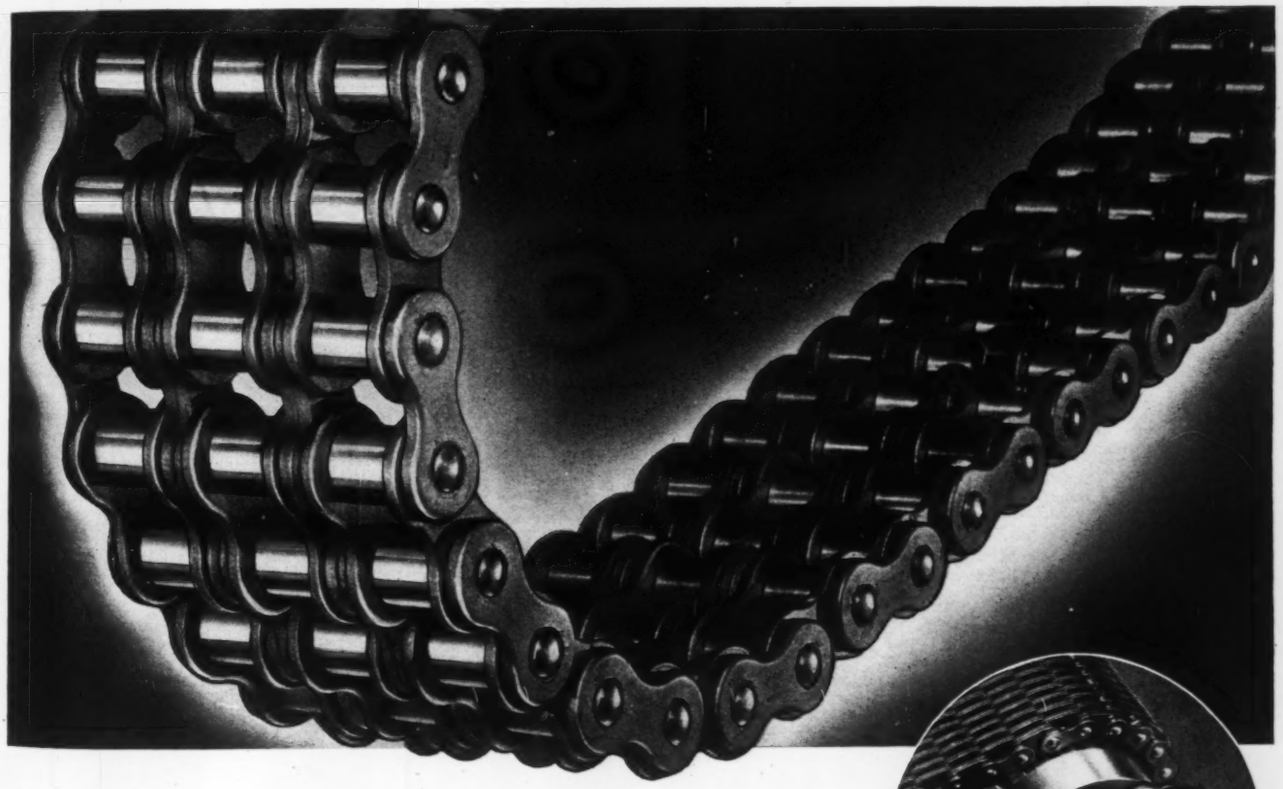

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